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2217/0009 (2013.01); *H03K 2217/0081*
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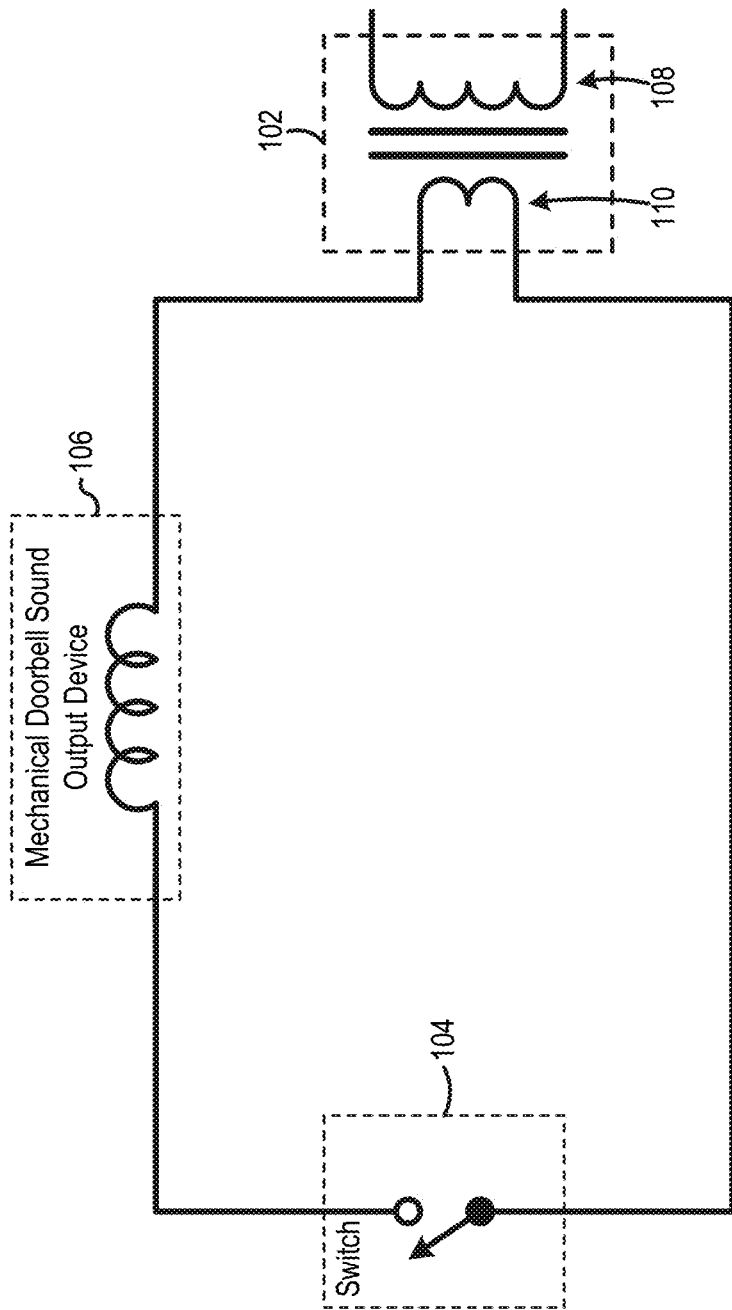


FIGURE 1
(PRIOR ART)

200

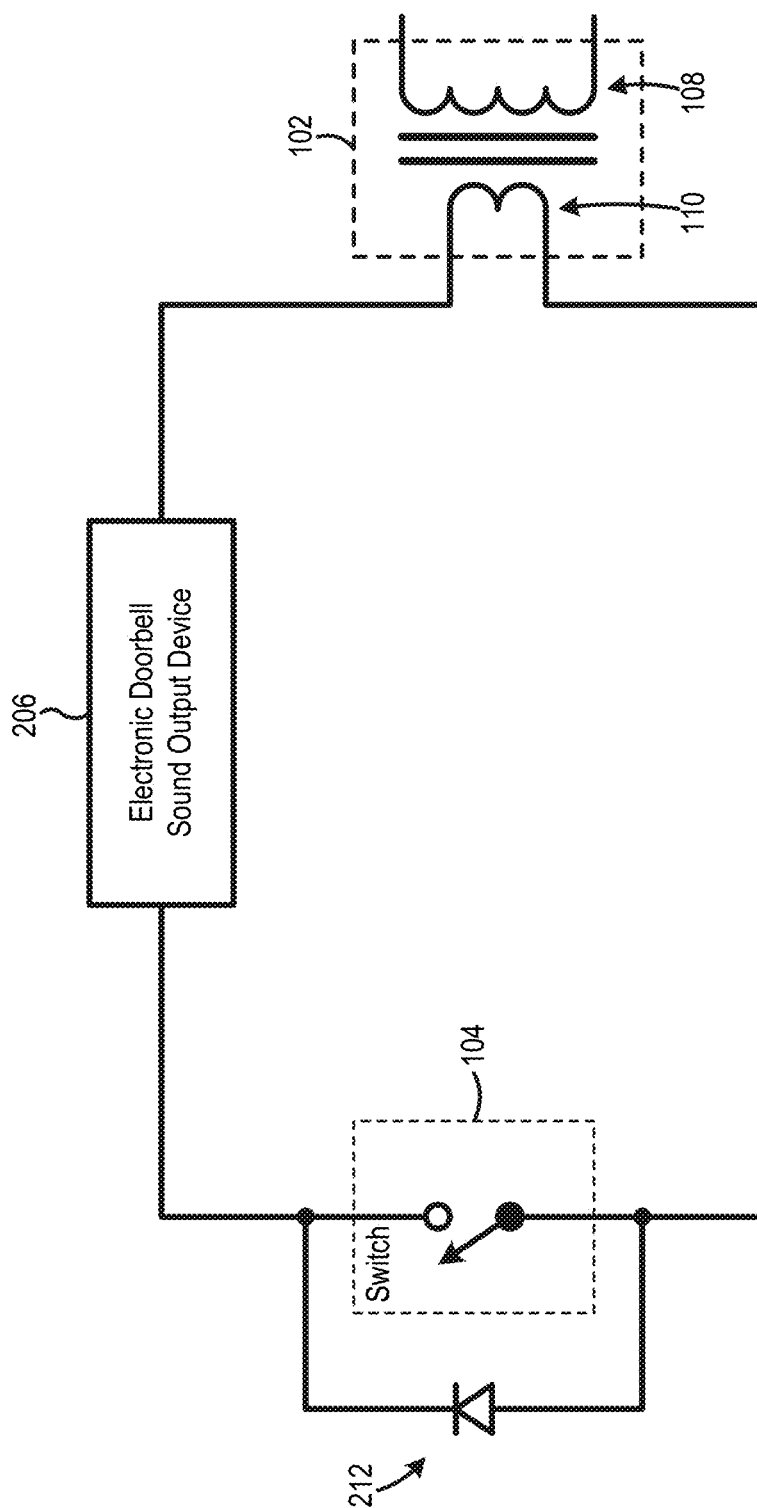


FIGURE 2
(PRIOR ART)

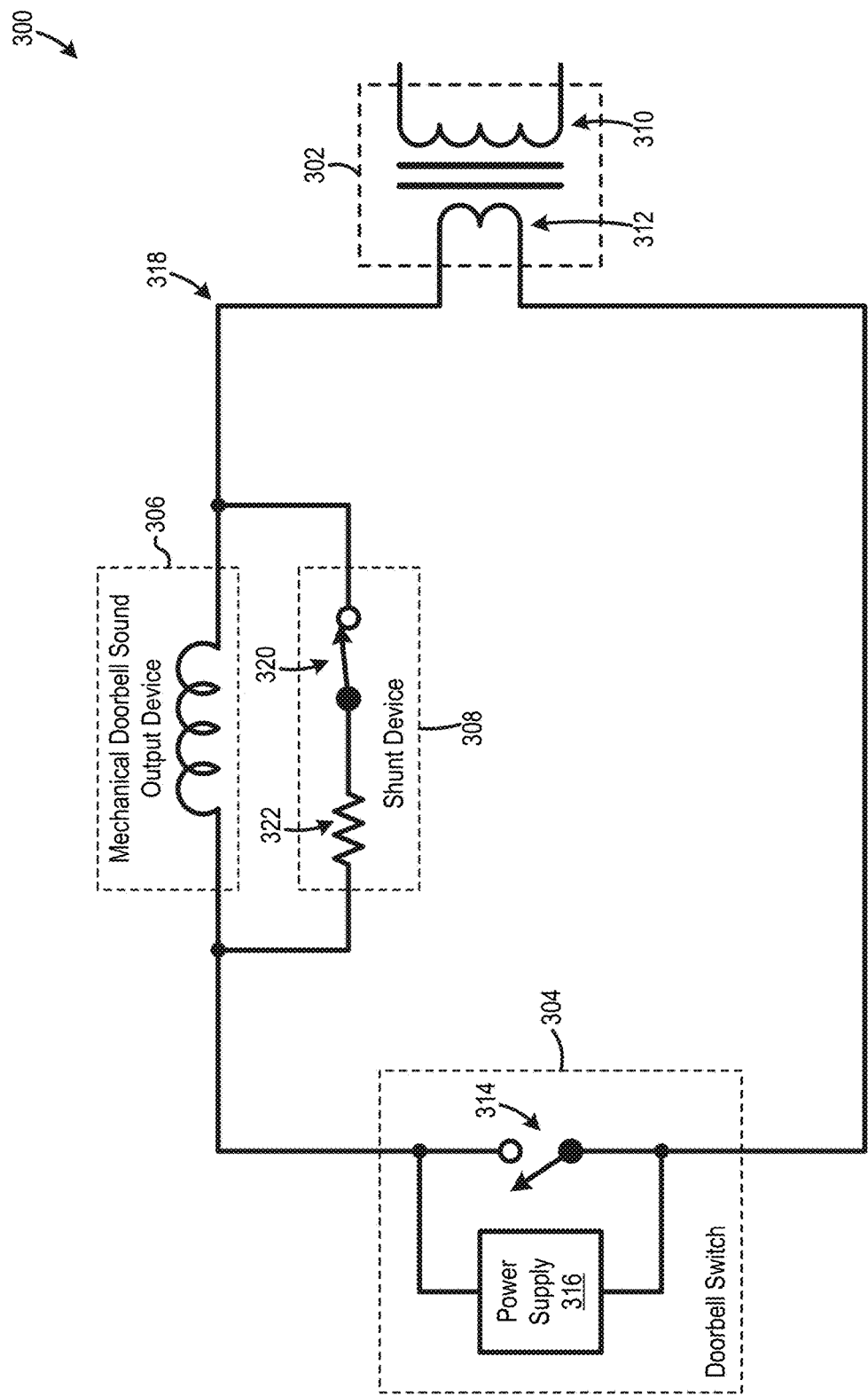


FIGURE 3
(PRIOR ART)

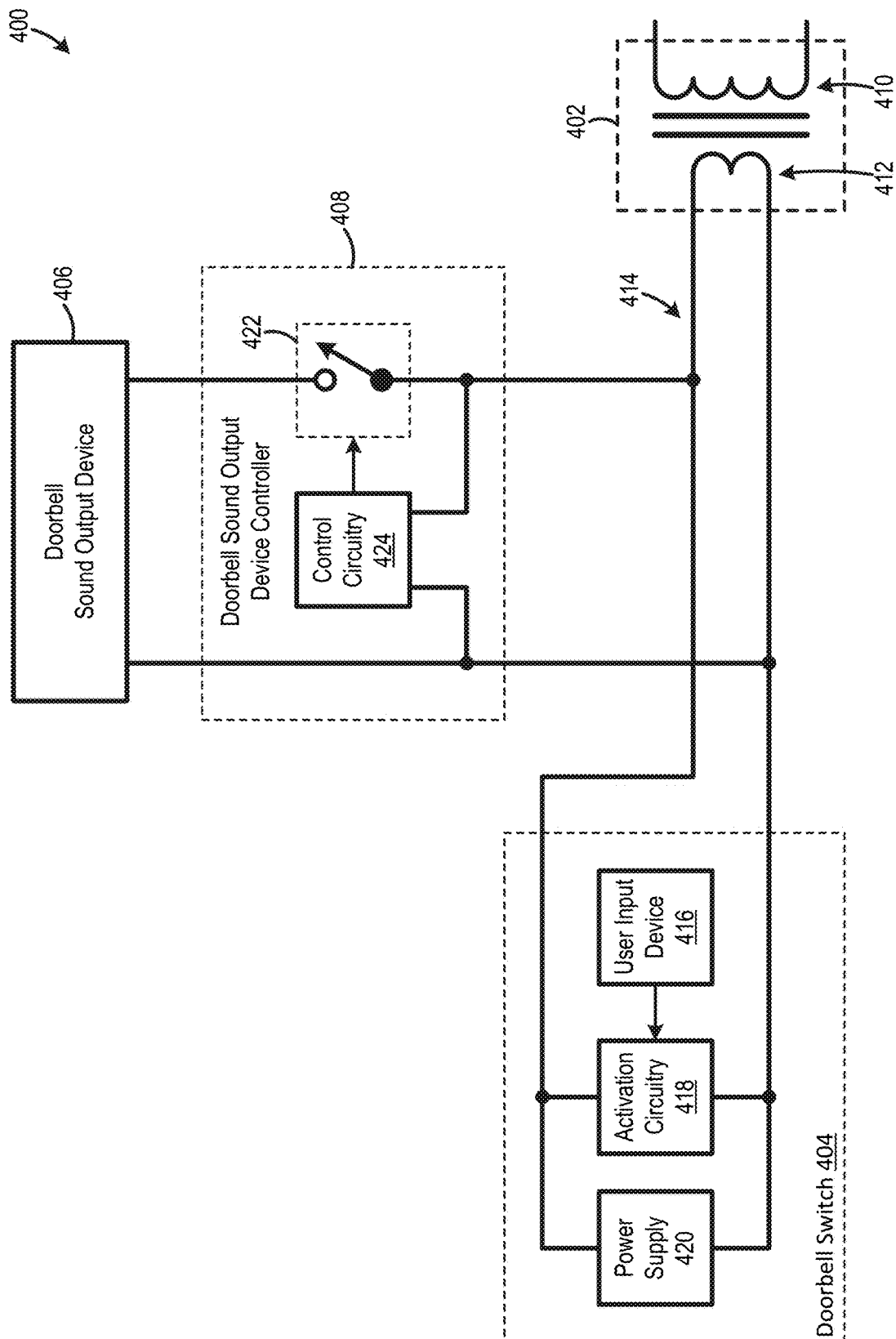


FIGURE 4

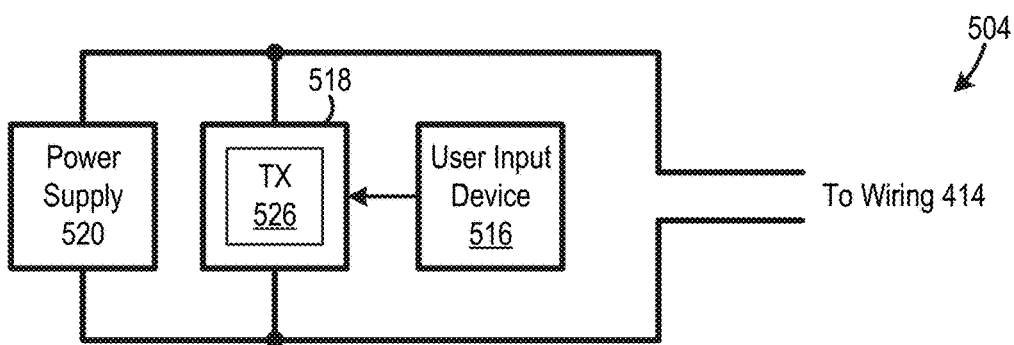


FIGURE 5

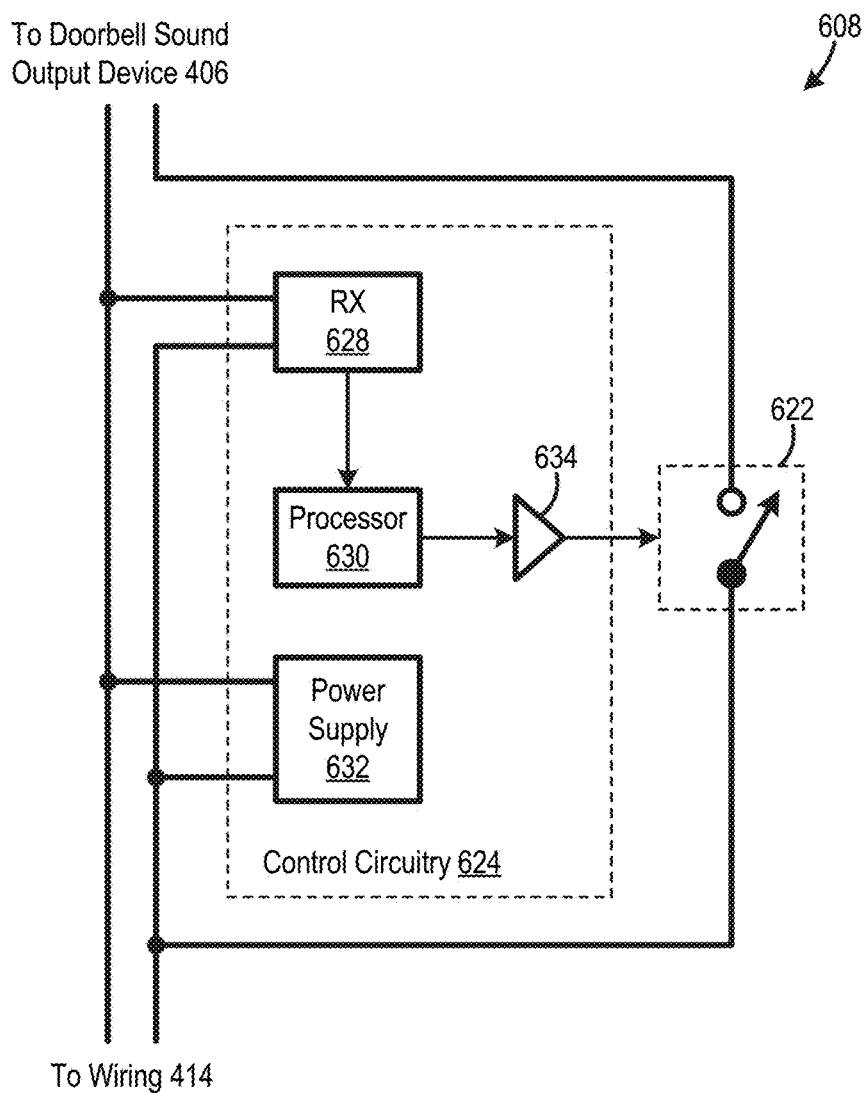


FIGURE 6

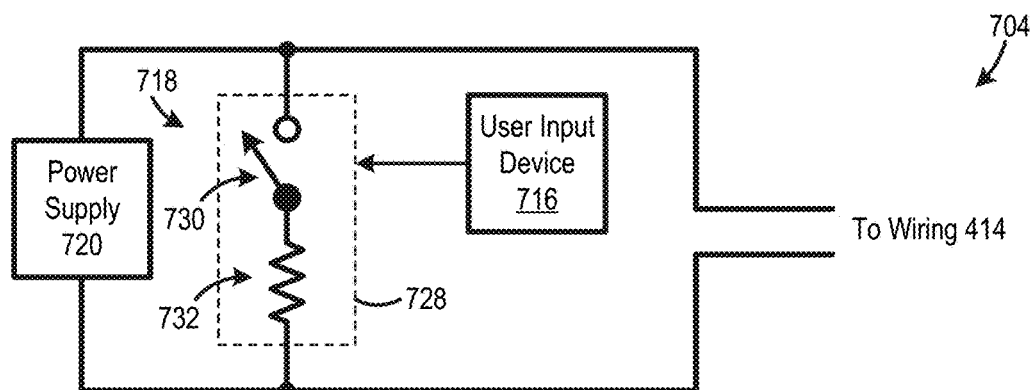


FIGURE 7

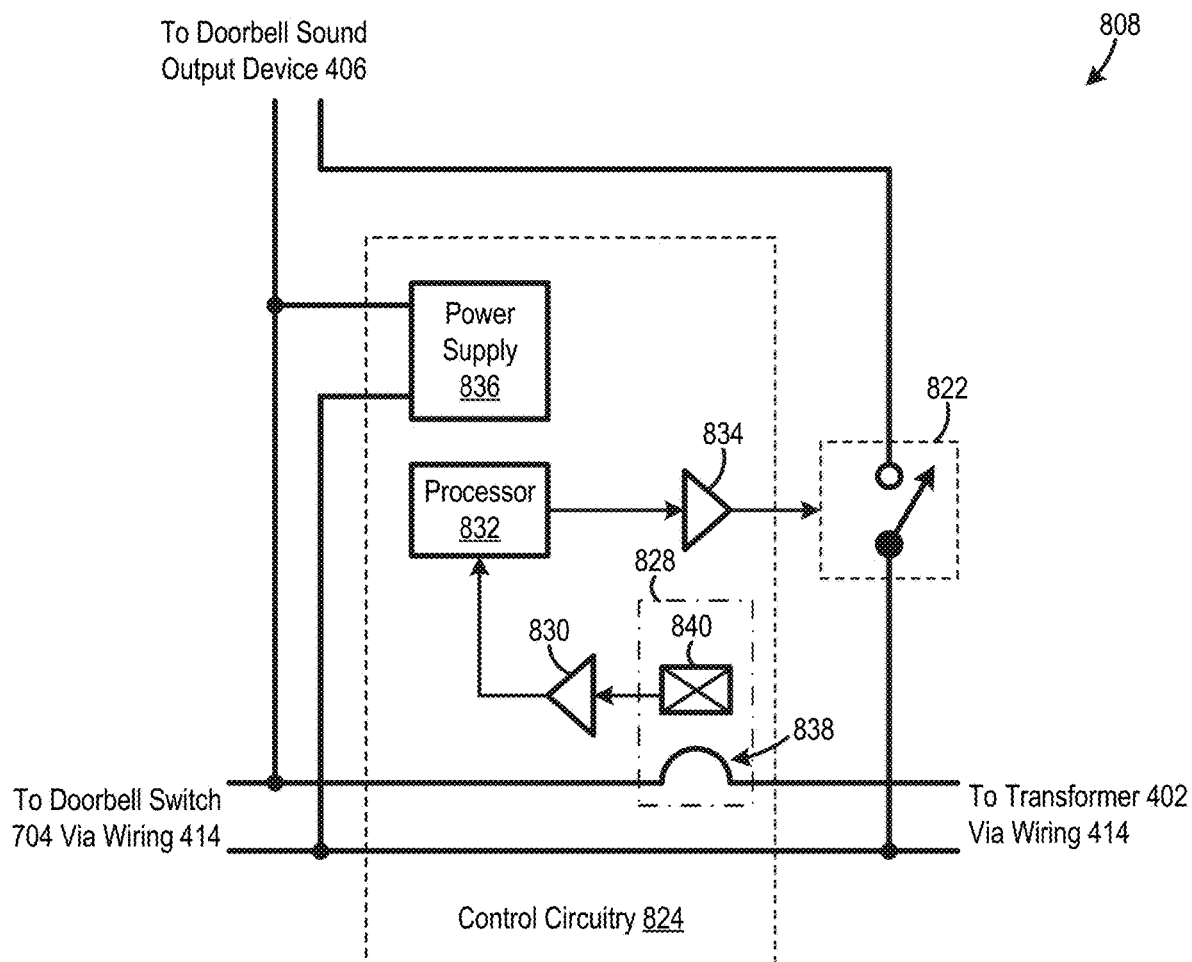


FIGURE 8

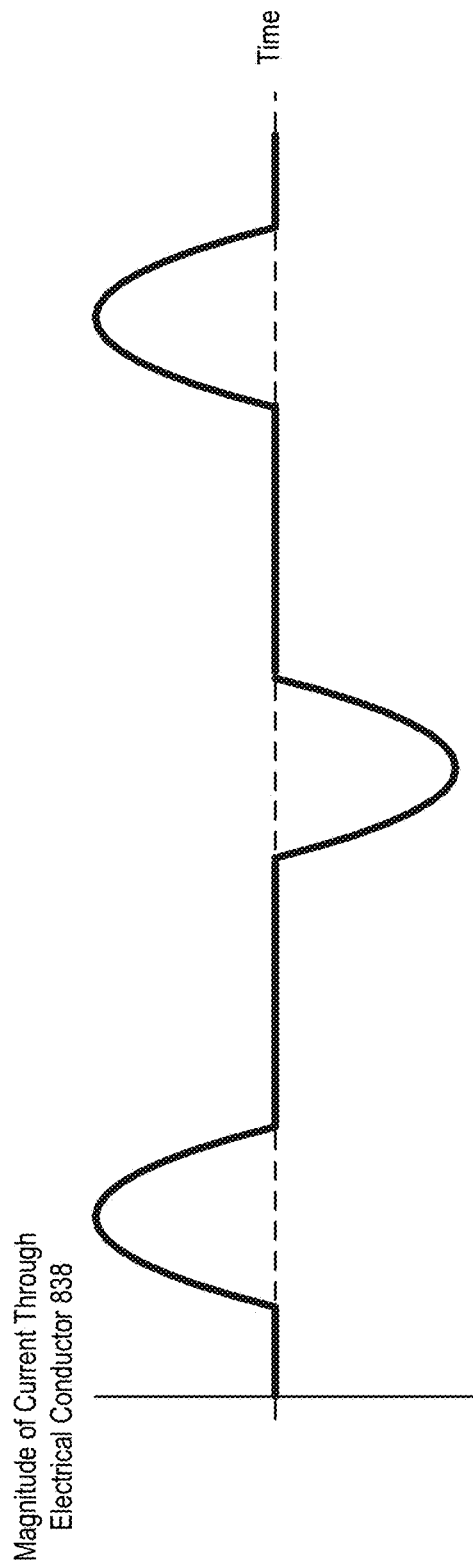


FIGURE 9

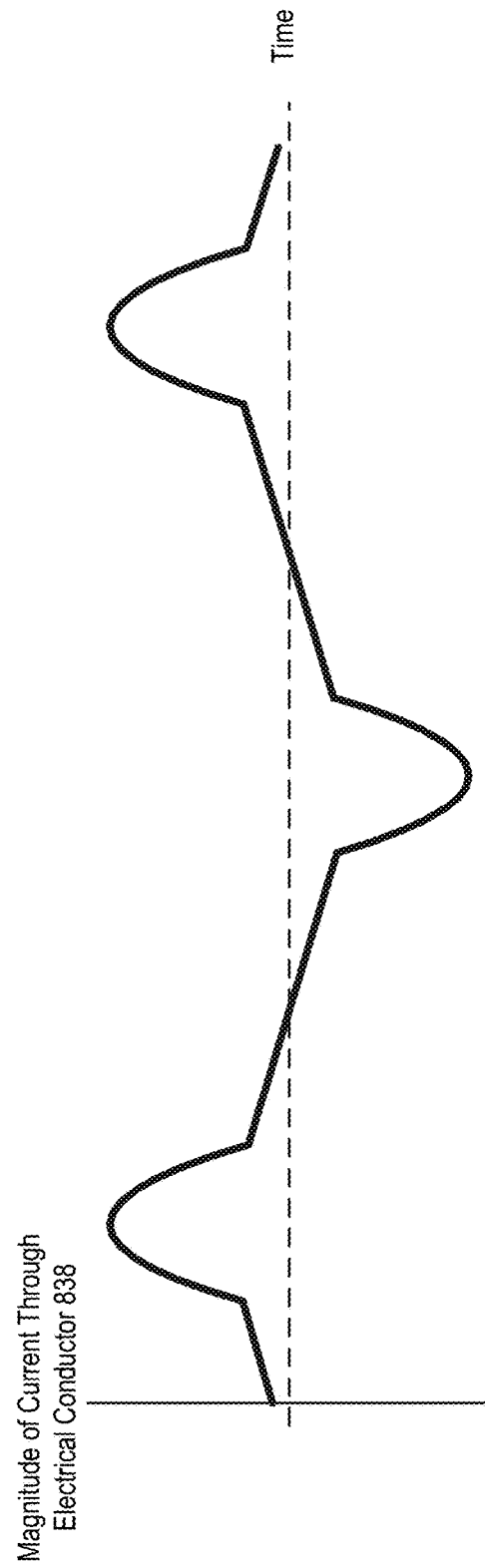


FIGURE 10

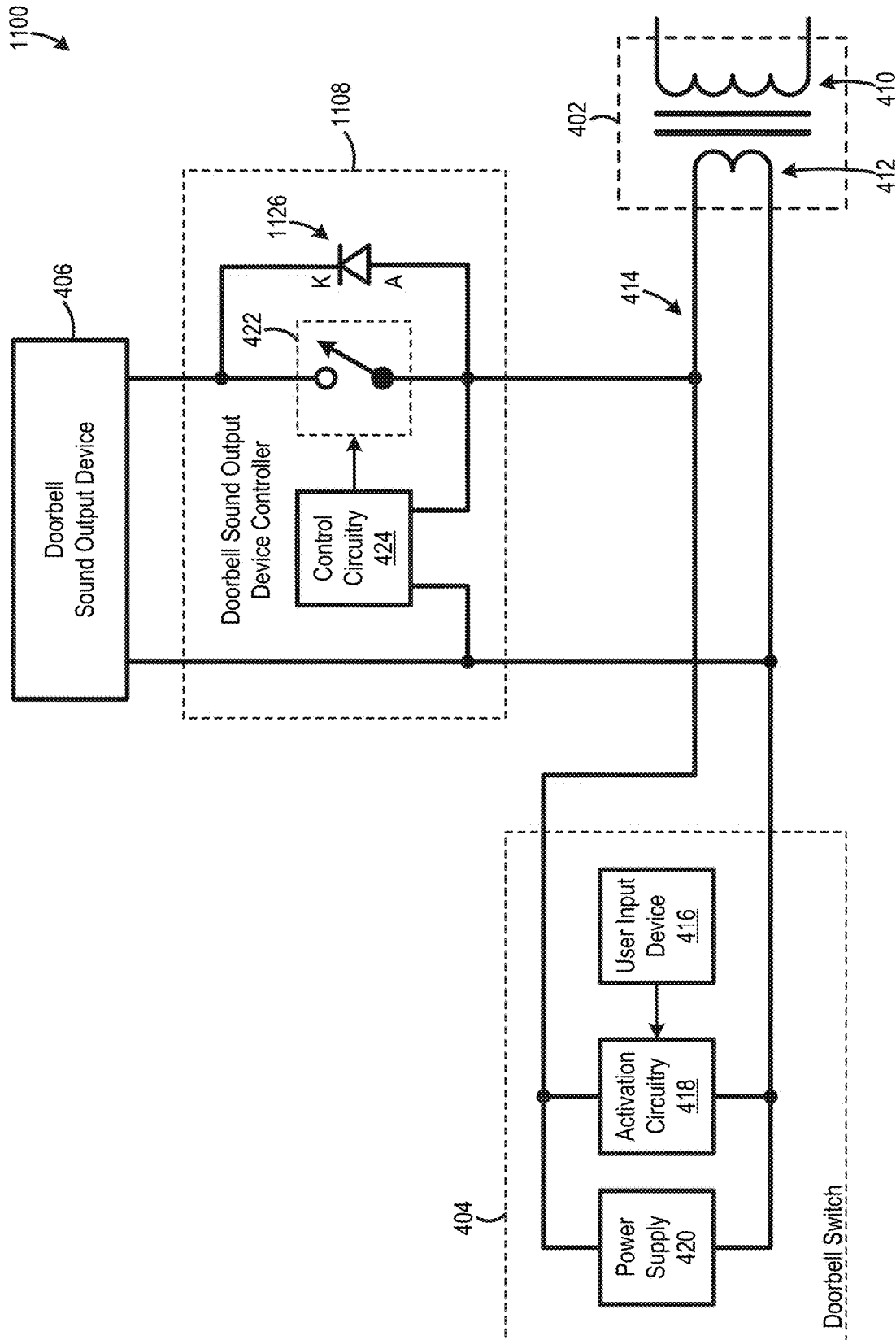


FIGURE 11

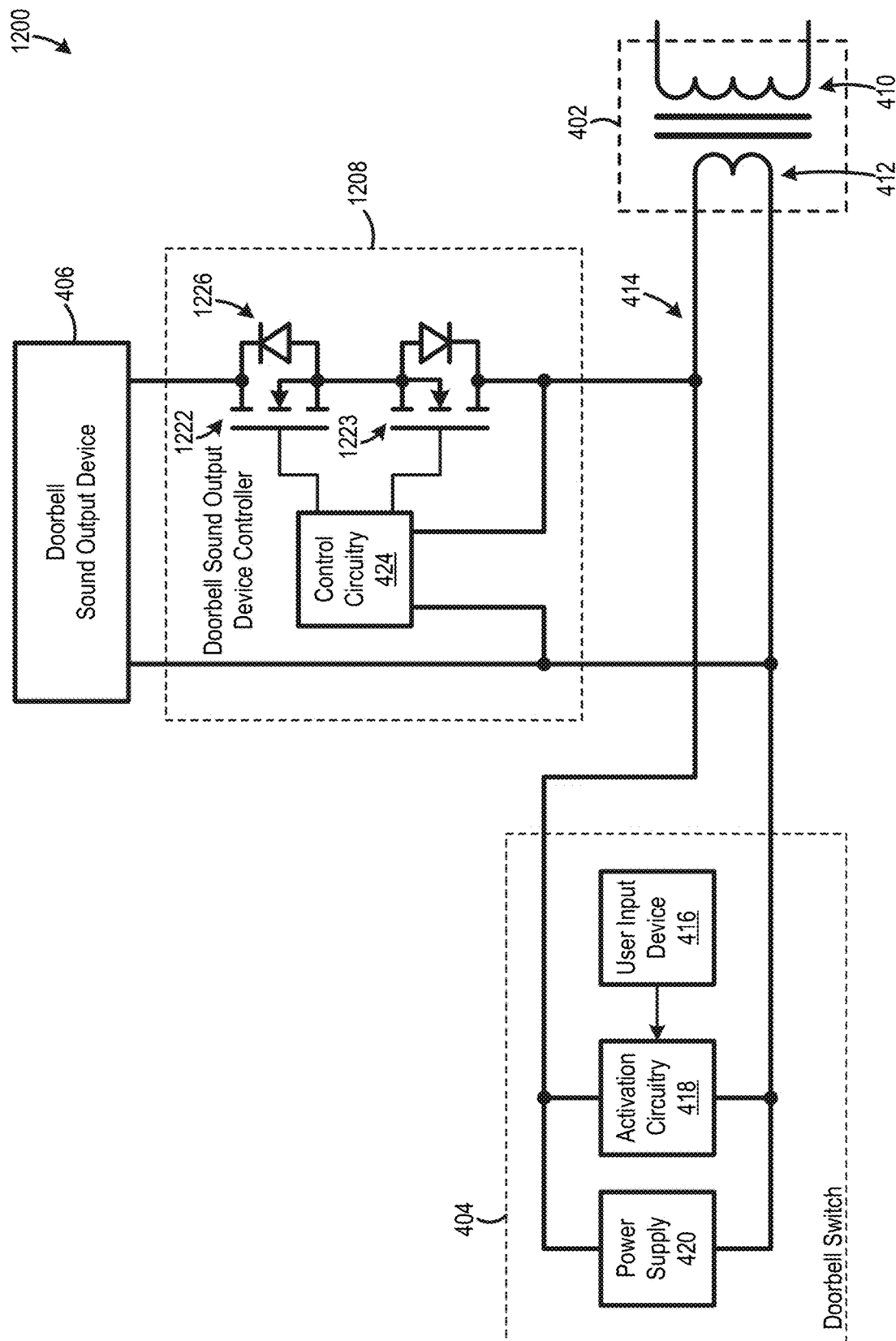


FIGURE 12

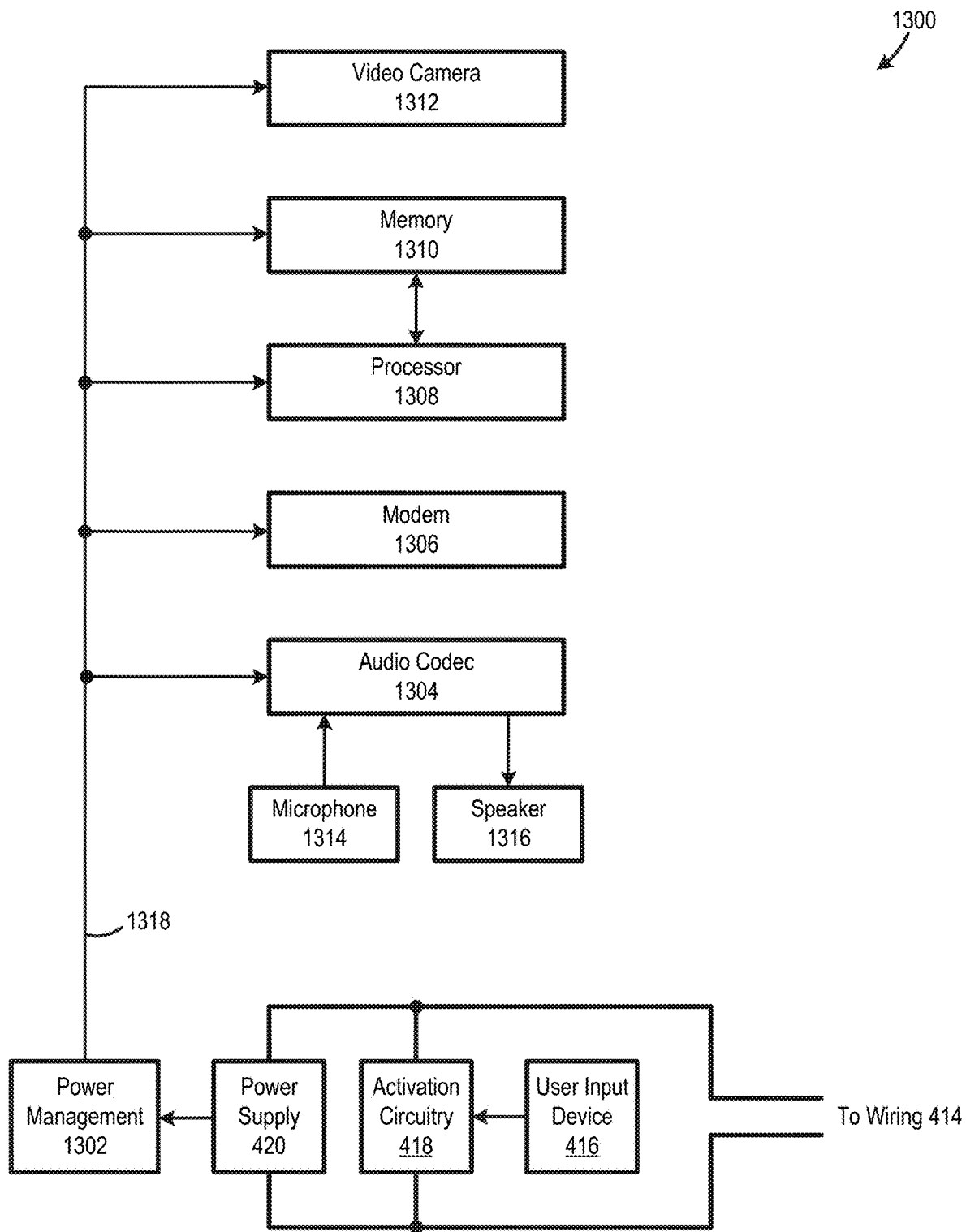


FIGURE 13

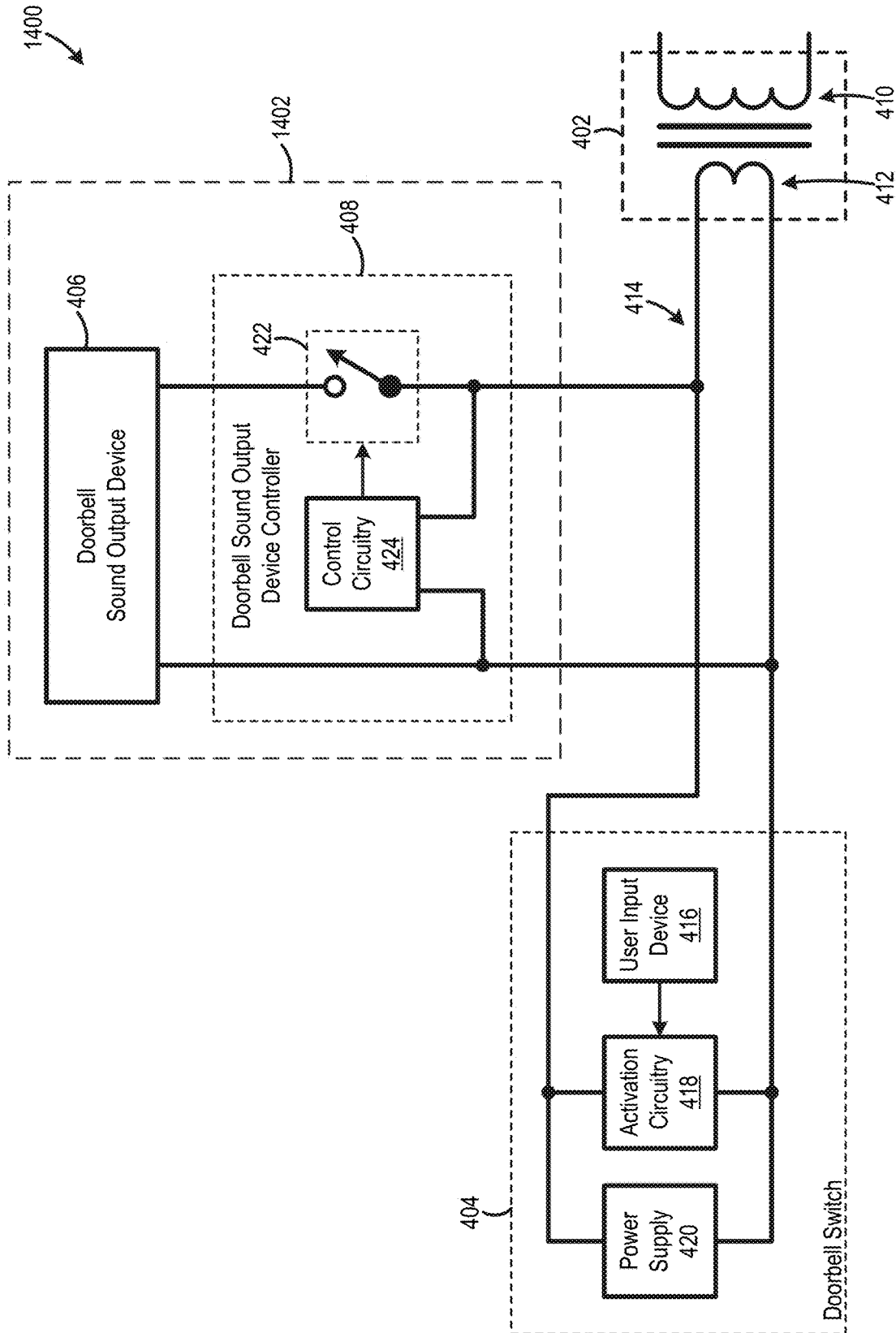


FIGURE 14

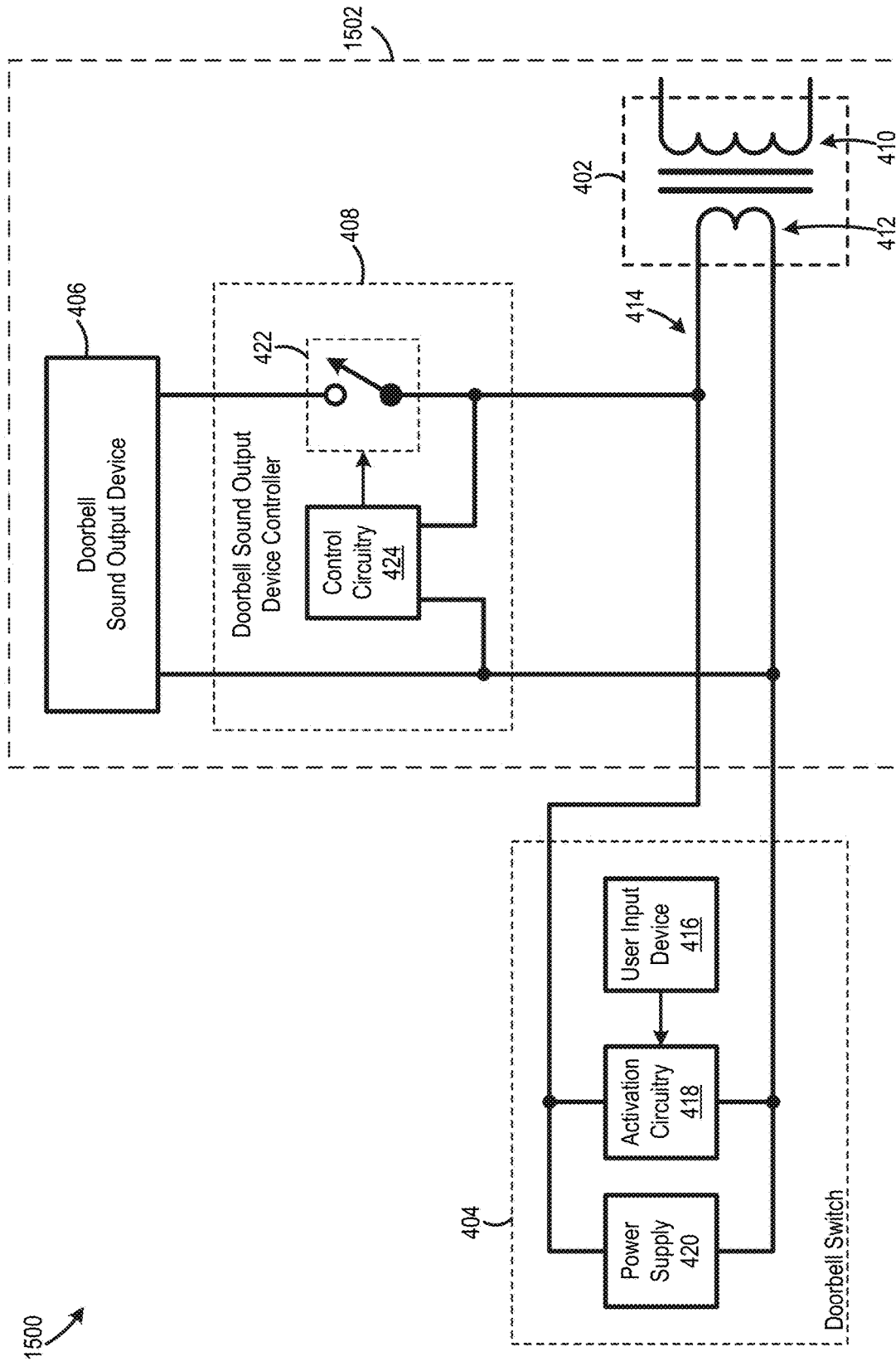


FIGURE 15

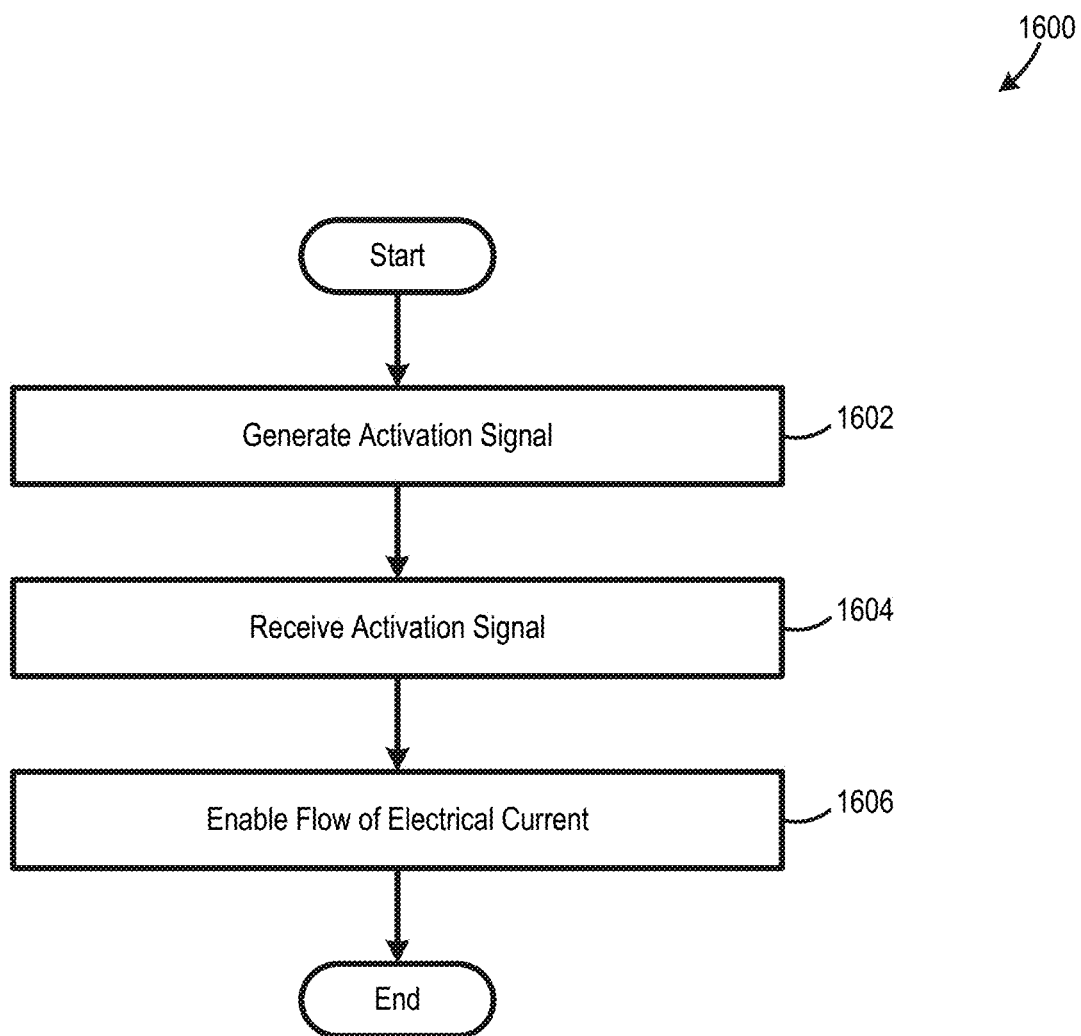


FIGURE 16

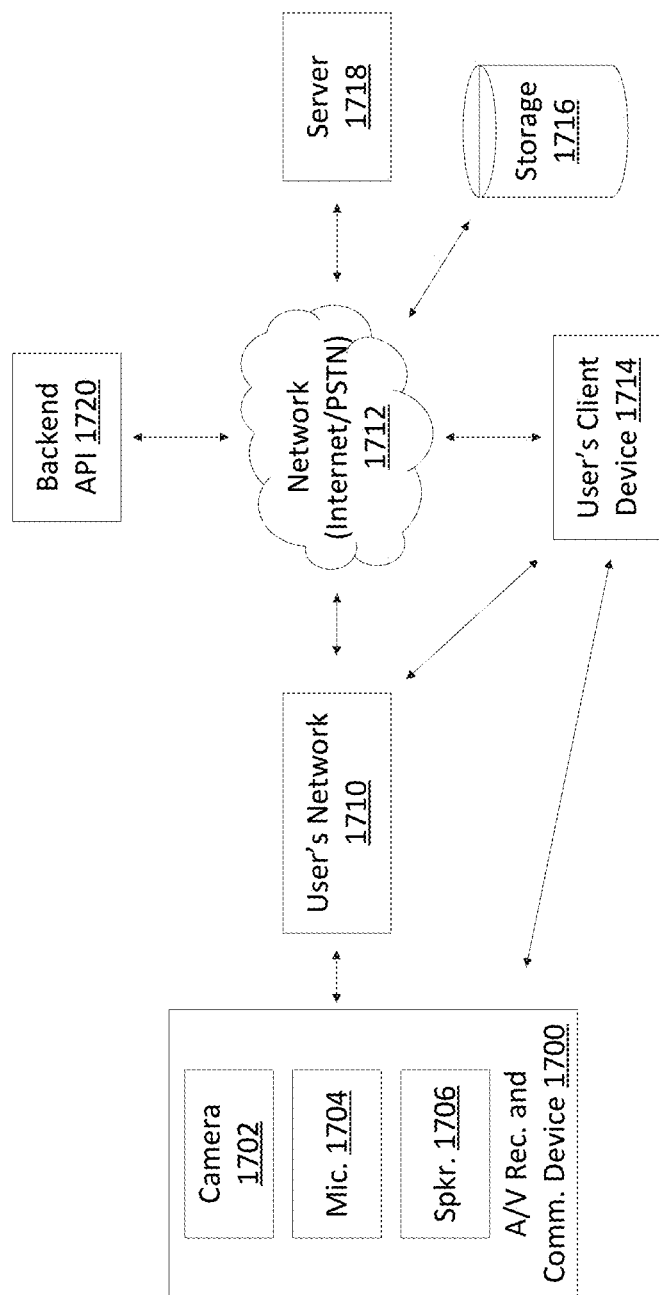


FIGURE 17

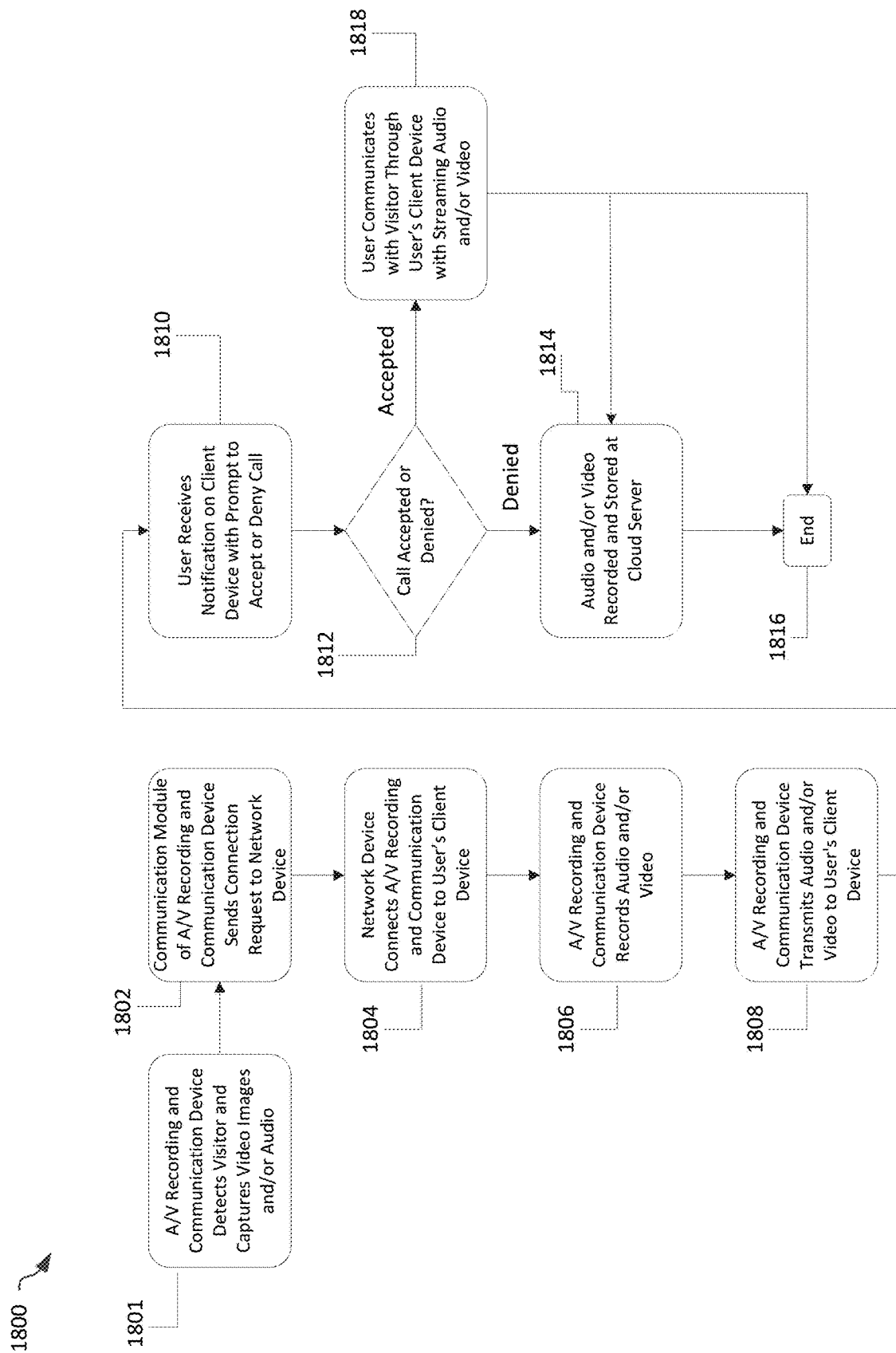


FIGURE 18

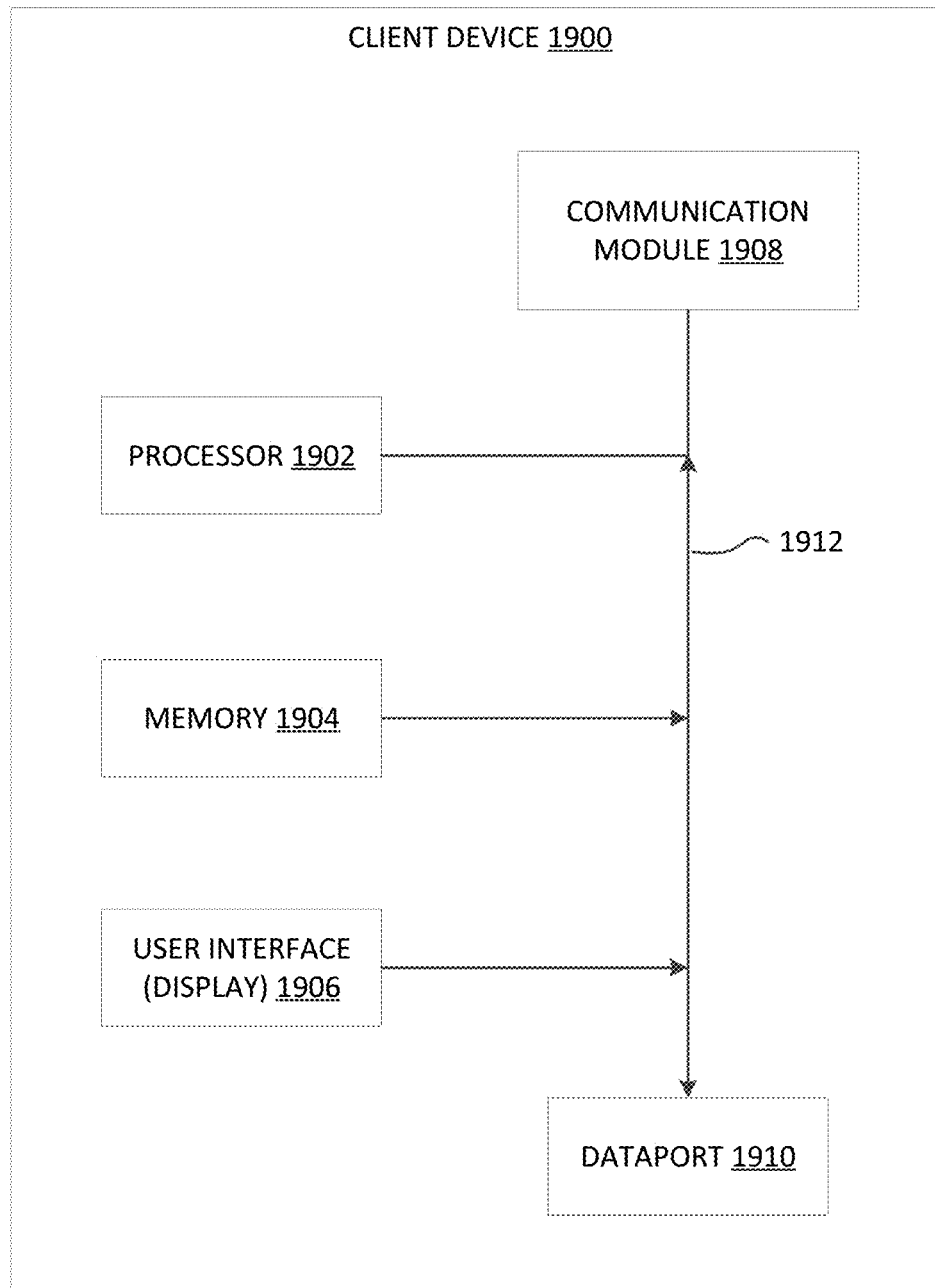


FIGURE 19

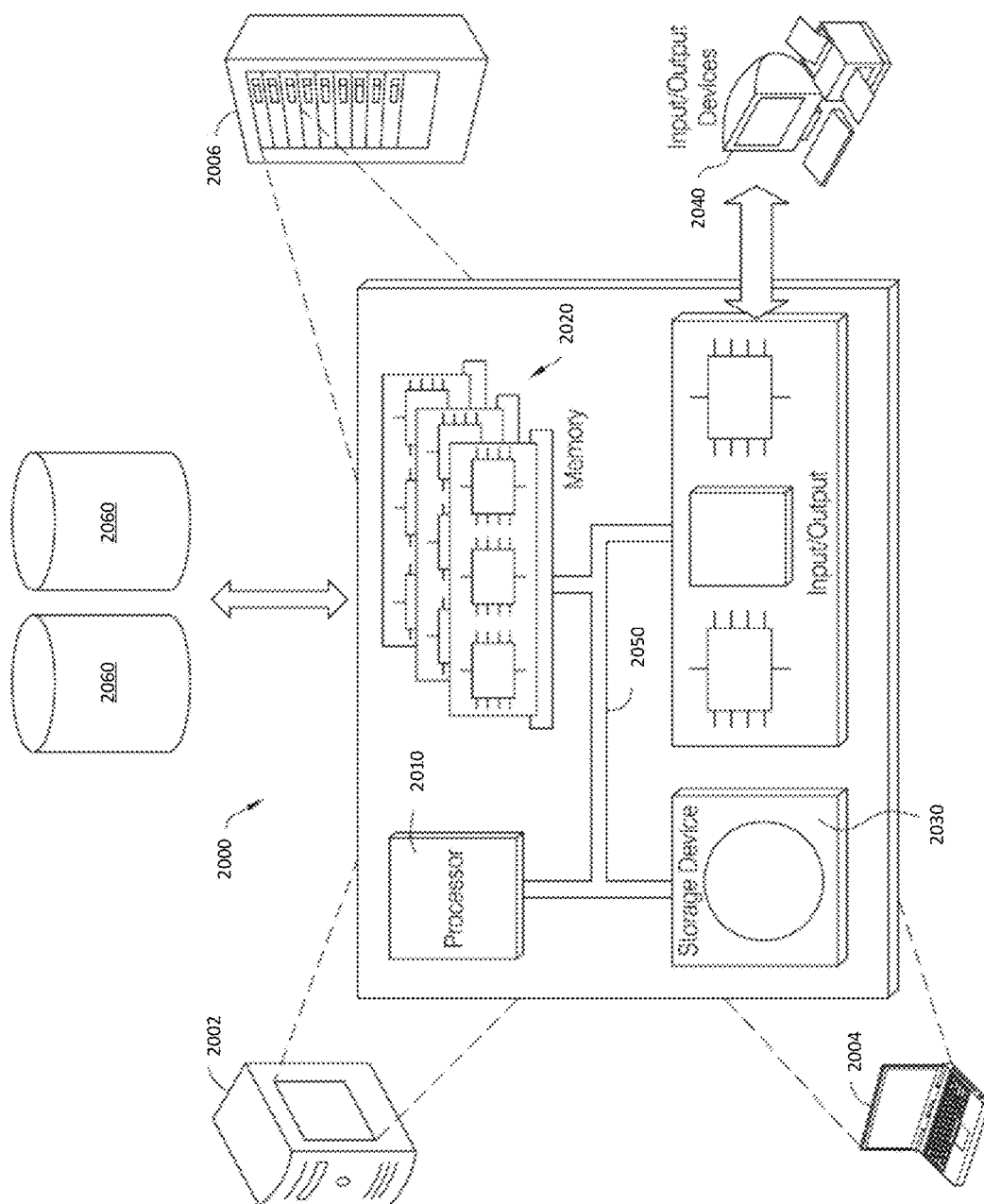


FIGURE 20

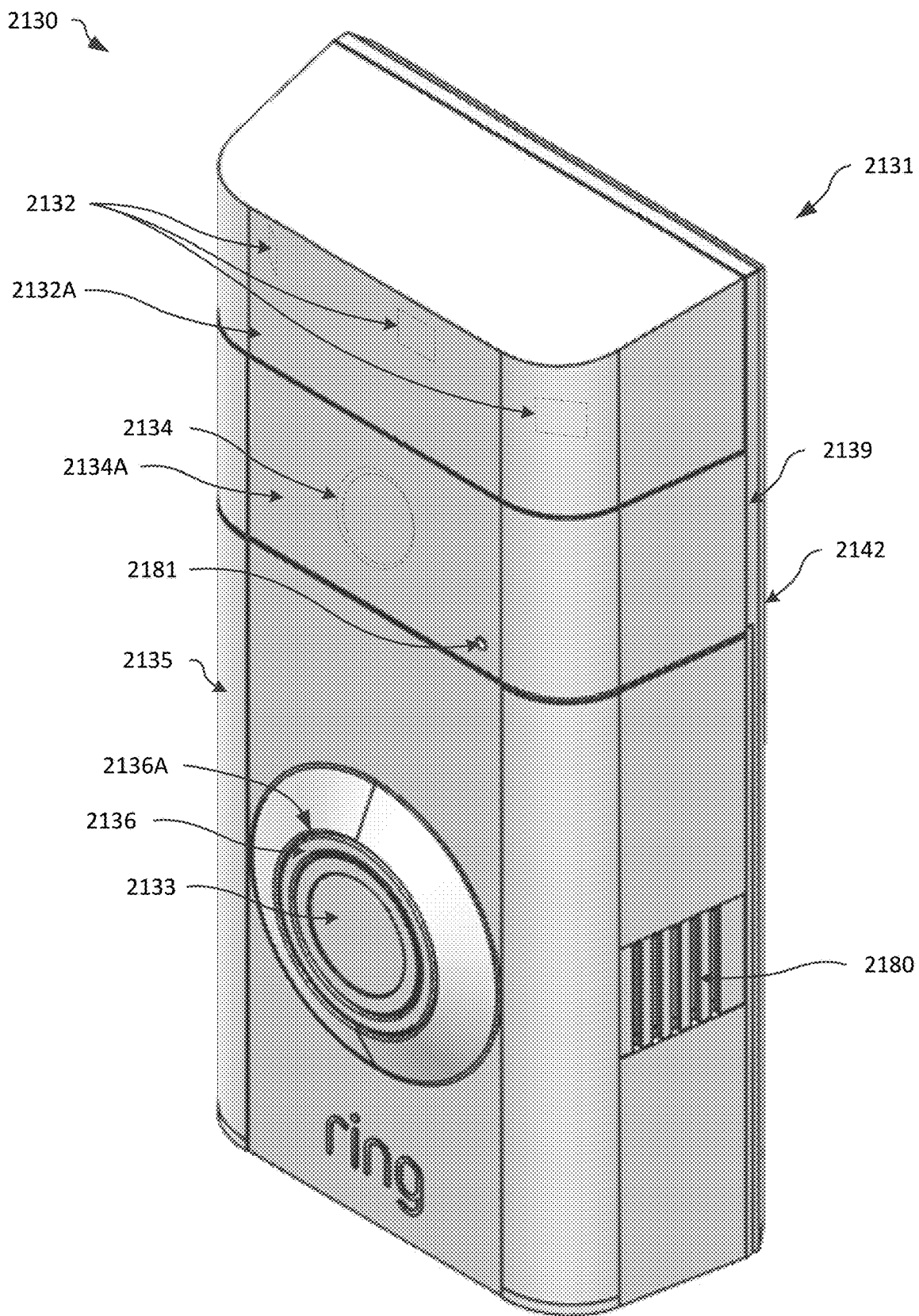


FIGURE 21

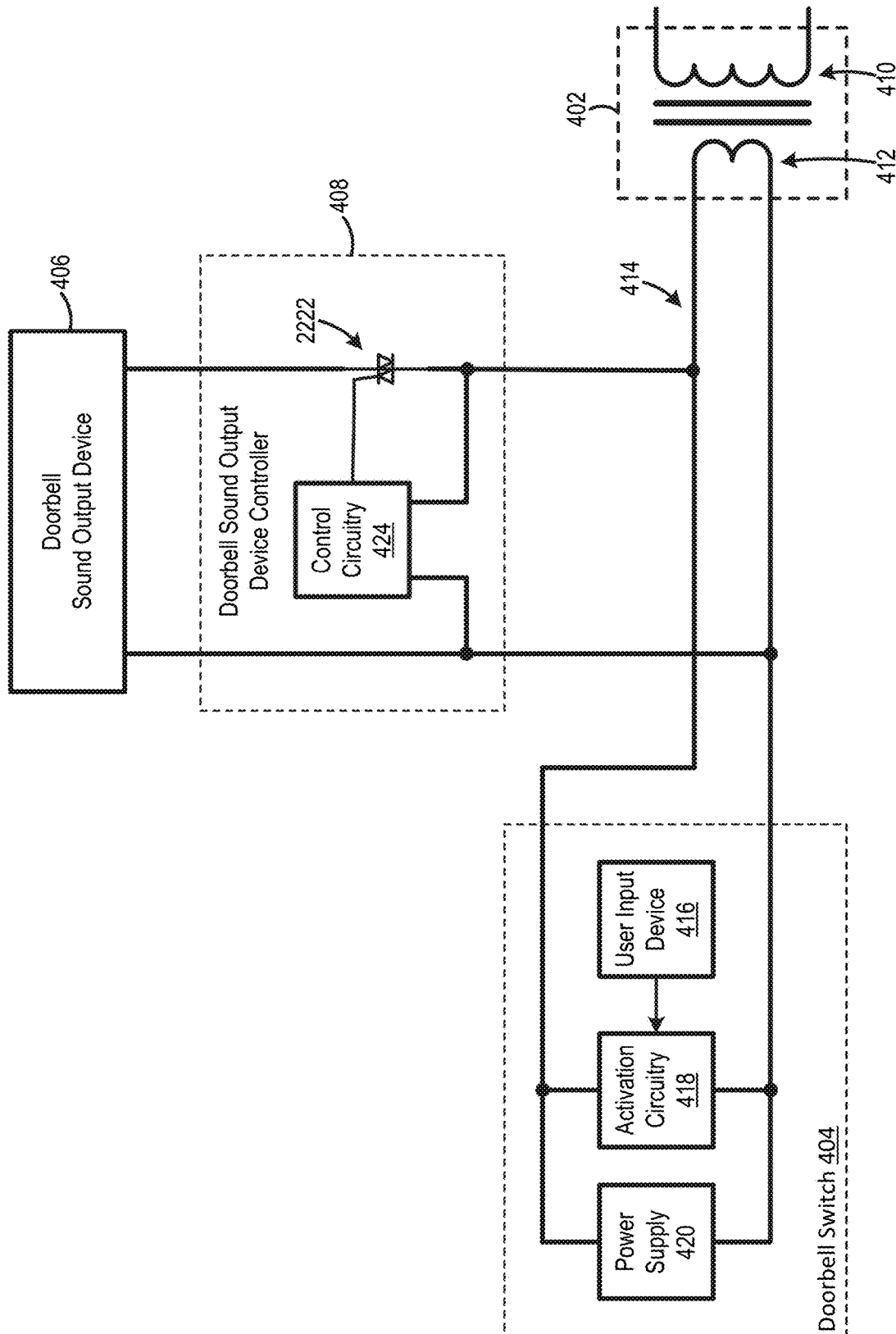


FIGURE 22

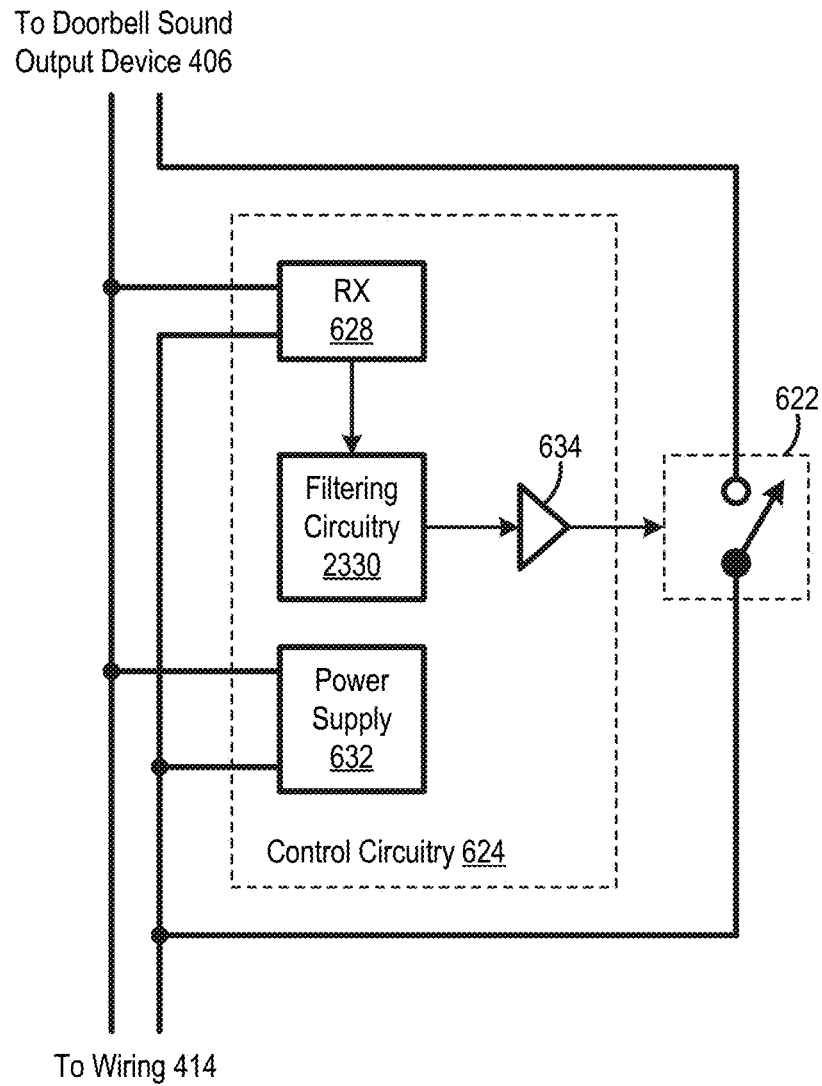


FIGURE 23

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DOORBELL SOUND OUTPUT DEVICE CONTROLLERS, DOORBELL SWITCHES, AND ASSOCIATED SYSTEMS AND METHODS

RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 15/868,920, filed on Jan. 11, 2018, which claims benefit of priority to U.S. Provisional Patent Application Ser. No. 62/445,184, filed on Jan. 11, 2017. Each of the above-mentioned applications is incorporated herein by reference.

BACKGROUND

Doorbells are widely used in buildings, such as to enable visitors to announce their presence. FIG. 1 schematically illustrates a prior-art doorbell system **100** including a step-down transformer **102**, a doorbell switch **104**, and a mechanical doorbell sound output device **106**. A primary winding **108** of the transformer **102** is electrically coupled to an alternating current (AC) electrical power source (not shown), and a secondary winding **110** of the transformer **102** is electrically coupled in series with the doorbell switch **104** and the doorbell sound output device **106**.

The doorbell switch **104** is normally open, and electrical current therefore normally does not flow through the mechanical doorbell sound output device **106**. When the doorbell switch **104** is pressed such that the switch is closed, electrical current flows through and energizes the mechanical doorbell sound output device **106**. Typically, this action produces a “ding” sound. When the doorbell switch **104** is released such that the switch is opened, a plunger of the mechanical doorbell sound output device **106** strikes a lower pitched metal plate, producing a “dong” sound. The mechanical doorbell sound output device **106** is schematically depicted herein as a solenoid coil, and mechanical aspects are not shown to promote illustrative clarity.

FIG. 2 schematically illustrates another prior-art doorbell system **200**. The doorbell system **200** is similar to the doorbell system **100** of FIG. 1, except that the mechanical doorbell sound output device **106** is replaced with an electronic doorbell sound output device **206**, and a semiconductor diode **212** is electrically coupled in parallel with the doorbell switch **104**. The semiconductor diode **212** provides half-wave rectified direct current (DC) electrical power to the electronic doorbell sound output device **206**, thereby enabling the doorbell sound output device **206** to be ready to receive a trigger signal. When the doorbell switch **104** is closed, the electronic doorbell sound output device **206** is triggered by the presence of an AC electrical current waveform flowing through the doorbell sound output device. When the doorbell switch **104** is released, DC electrical power is again provided to the electronic doorbell sound output device **206**, thereby electrically powering the electronic doorbell sound output device **206** and enabling the doorbell sound output device to continue to play a sound output device melody lasting a few to several seconds, even if the trigger signal is shorter than one second. Many electronic doorbell sound output devices on the market today operate in this manner, requiring a diode (e.g., the diode **212**) connected across the doorbell switch.

SUMMARY

One aspect of the present embodiments includes the realization that closure of a switching device in a conven-

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tional doorbell switch electrically bypasses a power supply of the doorbell switch. Consequently, if the doorbell switch is to operate continuously, a battery or other energy storage device must be provided to power the doorbell switch while the switching device is closed. The present embodiments solve this problem by generating an activation signal in a doorbell switch without interfering with power supply circuitry operation in the doorbell switch, and enabling flow of electrical current between a doorbell sound output device controller and a doorbell sound output device in response to receiving the activation signal at the doorbell sound output device controller. Doorbells including features of the present embodiments thus do not require a battery or other energy storage device to power the doorbell switch while the switching device is closed, which not only simplifies the structure of such doorbells, but also enables doorbells of the present embodiments to avoid drawbacks associated with batteries, such as their limited lifespan and poor cold weather performance.

In a first aspect, a doorbell sound output device controller includes (a) a switching device configured to control flow of electrical current between the doorbell sound output device controller and a doorbell sound output device and (b) control circuitry. The control circuitry is configured to control the switching device to enable flow of electrical current between the doorbell sound output device controller and the doorbell sound output device in response to receiving an activation signal from a doorbell switch external to the doorbell sound output device controller.

In some embodiments of the first aspect, the control circuitry includes a receiver configured to receive the activation signal from the doorbell switch.

In some embodiments of the first aspect, the receiver is configured to receive the activation signal via wiring electrically coupling the doorbell switch to the doorbell sound output device controller.

In some embodiments of the first aspect, the activation signal is selected from the group consisting of a simple tone and a modulated tone.

In some embodiments of the first aspect, the control circuitry includes current sense circuitry configured to receive the activation signal from the doorbell switch via a change in electrical current flowing between the doorbell sound output device controller and the doorbell switch.

In some embodiments of the first aspect, the current sense circuitry includes (a) an electrical conductor configured to be electrically coupled to the doorbell switch, and (b) a Hall effect sensor configured to sense a magnetic field generated by electrical current flowing through the electrical conductor.

In some embodiments of the first aspect, the control circuitry is further configured to detect the activation signal in response to a change in an amount of time that a magnitude of the electrical current flowing between the doorbell sound output device controller and the doorbell switch is zero.

In some embodiments of the first aspect, the control circuitry includes filtering circuitry configured to filter the activation signal from other signals received by the control circuitry.

In some embodiments of the first aspect, the control circuitry includes (a) a power supply configured to provide electric power to the control circuitry, and (b) driver circuitry configured to drive the switching device.

In some embodiments of the first aspect, the switching device is configured to be electrically coupled in series with the doorbell sound output device.

In some embodiments of the first aspect, the switching device includes a triac.

In some embodiments of the first aspect, the doorbell sound output device controller further includes a diode device electrically coupled in parallel with the switching device, such that the diode device provides a path for direct current between the doorbell sound output device controller and the doorbell sound output device.

In some embodiments of the first aspect, the switching device includes first and second metal oxide semiconductor field effect transistors electrically coupled in series, and the diode device is a body diode of the first metal oxide semiconductor field effect transistor.

In some embodiments of the first aspect, the control circuitry is further configured to receive a configuration command to cause the second metal oxide semiconductor field effect transistor to continuously operate in its conductive operating state, such that the body diode of the first metal oxide semiconductor field effect transistor provides a path for direct current between the doorbell sound output device controller and the doorbell sound output device.

In some embodiments of the first aspect, the control circuitry is further configured to receive the configuration command from the doorbell switch.

In some embodiments of the first aspect, the control circuitry is further configured to control a duration that the switching device operates in its conductive state in response to receiving the activation signal from the doorbell switch.

In some embodiments of the first aspect, the control circuitry is further configured to enable adjustment of the duration that the switching device operates in its conductive state in response to receiving the activation signal from the doorbell switch.

In a second aspect, a doorbell switch includes (a) a user input device configured to receive a user command to activate a doorbell sound output device, and (b) a transmitter configured to generate an activation signal on wiring electrically coupling the doorbell switch to a doorbell sound output device controller, in response to the user input device receiving the user command to activate the doorbell sound output device.

In some embodiments of the second aspect, the doorbell switch further includes power supply circuitry configured to (a) receive input electrical power via the wiring electrically coupling the doorbell switch to the doorbell sound output device controller and (b) electrically power the doorbell switch.

In some embodiments of the second aspect, the transmitter is further configured to generate the activation signal such that the activation signal is selected from the group consisting of a simple tone and a modulated tone.

In some embodiments of the second aspect, the user input device includes a touch-activated switch.

In some embodiments of the second aspect, the doorbell switch further includes a video camera configured to generate video image data representing a scene proximate to the doorbell switch.

In some embodiments of the second aspect, the doorbell switch further includes a microphone configured to generate sound data representing sound proximate to the doorbell switch.

In some embodiments of the second aspect, the doorbell switch further includes a speaker configured to generate sound in response to a signal received by the doorbell switch from a device external to the doorbell switch.

In a third aspect, a doorbell switch includes (a) a user input device configured to receive a user command to

activate a doorbell sound output device, and (b) perturbation circuitry configured to generate an activation signal on wiring electrically coupling the doorbell switch to a doorbell sound output device controller by changing electrical current flowing through the wiring, in response to the user input device receiving the user command to activate the doorbell sound output device.

In some embodiments of the third aspect, the doorbell switch further includes power supply circuitry configured to (a) receive input electrical power via the wiring electrically coupling the doorbell switch to the doorbell sound output device controller and (b) electrically power the doorbell switch.

In some embodiments of the third aspect, the perturbation circuitry includes a perturbation switching device and an impedance device electrically coupled in series across the wiring electrically coupling the doorbell switch to the doorbell sound output device controller.

In some embodiments of the third aspect, the user input device includes a touch-activated switch.

In some embodiments of the third aspect, the doorbell switch further includes a video camera configured to generate video image data representing a scene proximate to the doorbell switch.

In some embodiments of the third aspect, the doorbell switch further includes a microphone configured to generate sound data representing sound proximate to the doorbell switch.

In some embodiments of the third aspect, the doorbell switch further includes a speaker configured to generate sound in response to a signal received by the doorbell switch from a device external to the doorbell switch.

In a fourth aspect, a doorbell includes a doorbell switch and a doorbell sound output device controller. The doorbell switch includes (a) a user input device configured to receive a user command to activate a doorbell sound output device, and (b) activation circuitry configured to generate an activation signal in response to the user input device receiving the user command to activate the doorbell sound output device. The doorbell sound output device controller includes (a) a switching device configured to control flow of electrical current between the doorbell sound output device controller and the doorbell sound output device, and (b) control circuitry configured to control the switching device to enable flow of electrical current between the doorbell sound output device controller and the doorbell sound output device in response to receiving the activation signal from the doorbell switch.

In some embodiments of the fourth aspect, the doorbell switch further includes power supply circuitry configured to (a) receive input electrical power via wiring electrically coupling the doorbell switch to the doorbell sound output device controller and (b) electrically power the doorbell switch.

In some embodiments of the fourth aspect, the activation circuitry includes a transmitter configured to generate the activation signal on the wiring electrically coupling the doorbell switch to the doorbell sound output device controller.

In some embodiments of the fourth aspect, the transmitter is further configured to generate the activation signal such that the activation signal is selected from the group consisting of a simple tone and a modulated tone.

In some embodiments of the fourth aspect, the activation circuitry is further configured to generate the activation signal by changing electrical current flowing through the

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wiring electrically coupling the doorbell switch to the doorbell sound output device controller.

In some embodiments of the fourth aspect, the activation circuitry includes a perturbation switching device and an impedance device electrically coupled in series across the wiring electrically coupling the doorbell switch to the doorbell sound output device controller.

In some embodiments of the fourth aspect, the doorbell switch further includes a video camera configured to generate video image data representing a scene proximate to the doorbell.

In some embodiments of the fourth aspect, the control circuitry of the doorbell sound output device controller includes a receiver configured to receive the activation signal from the doorbell switch via the wiring electrically coupling the doorbell switch to the doorbell sound output device controller.

In some embodiments of the fourth aspect, the control circuitry of the doorbell sound output device controller includes current sense circuitry configured to receive the activation signal from the doorbell switch via a change in electrical current flowing between the doorbell sound output device controller and the doorbell switch.

In some embodiments of the fourth aspect, the current sense circuitry includes: (a) an electrical conductor configured to be electrically coupled to the doorbell switch, and (b) a Hall effect sensor configured to sense a magnetic field generated by electrical current flowing through the electrical conductor.

In a fifth aspect, a method for operating a doorbell sound output device includes (a) generating an activation signal at a doorbell switch in response to a user command to activate the doorbell sound output device, (b) receiving the activation signal at a doorbell sound output device controller external to the doorbell switch, and (c) in response to receiving the activation signal at the doorbell sound output device controller, enabling flow of electrical current between the doorbell sound output device controller and the doorbell sound output device.

In some embodiments of the fifth aspect, the method further includes transmitting the activation signal from the doorbell switch to the doorbell sound output device controller via wiring electrically coupling the doorbell switch to the doorbell sound output device controller.

In some embodiments of the fifth aspect, the method further includes electrically powering the doorbell switch via the wiring electrically coupling the doorbell switch to the doorbell sound output device controller while transmitting the activation signal from the doorbell switch to the doorbell sound output device controller.

In some embodiments of the fifth aspect, generating the activation signal at the doorbell switch includes generating a tone selected from the group consisting of a simple tone and a modulated tone.

In some embodiments of the fifth aspect, generating the activation signal at the doorbell switch includes changing electrical current flowing through the wiring electrically coupling the doorbell switch to the doorbell sound output device controller.

In some embodiments of the fifth aspect, the method further includes generating video image data representing a scene proximate to the doorbell switch.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating a prior-art doorbell system including a mechanical doorbell sound output device.

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FIG. 2 is a schematic diagram illustrating a prior-art doorbell system including an electronic doorbell sound output device.

FIG. 3 is a schematic diagram illustrating a prior-art doorbell system including a shunt device.

FIG. 4 is a schematic diagram illustrating a doorbell system including a doorbell sound output device controller, according to an embodiment.

FIG. 5 is a schematic diagram illustrating a doorbell switch including a transmitter, according to an embodiment.

FIG. 6 is a schematic diagram illustrating a doorbell sound output device controller including a receiver, according to an embodiment.

FIG. 7 is a schematic diagram illustrating a doorbell switch including perturbation circuitry, according to an embodiment.

FIG. 8 is a schematic diagram illustrating a doorbell sound output device controller including current sense circuitry, according to an embodiment.

FIG. 9 is an example graph of magnitude of current through an electrical conductor of the FIG. 8 doorbell sound output device controller when a perturbation switching device is open, according to an embodiment.

FIG. 10 is an example graph of magnitude of current through an electrical conductor of the FIG. 8 doorbell sound output device controller when a perturbation switching device is closed, according to an embodiment.

FIG. 11 is a schematic diagram illustrating a doorbell system including a doorbell sound output device controller with a diode device electrically coupled in parallel with a switching device, according to an embodiment.

FIG. 12 is a schematic diagram illustrating a doorbell system where a doorbell sound output device controller includes a switching device implemented by two metal oxide semiconductor field effect transistors, according to an embodiment.

FIG. 13 is a schematic diagram illustrating a doorbell switch configured as a video doorbell, according to an embodiment.

FIG. 14 is a schematic diagram illustrating a doorbell system where a doorbell sound output device and a doorbell sound output device controller are integrated in a common package, according to an embodiment.

FIG. 15 is a schematic diagram illustrating a doorbell system where a doorbell sound output device, a doorbell sound output device controller, and a transformer are integrated in a common package, according to an embodiment.

FIG. 16 is a flowchart illustrating a method for operating a doorbell sound output device, according to an embodiment.

FIG. 17 is a functional block diagram illustrating a system for streaming and storing audio/video (A/V) content captured by a device, according to an embodiment.

FIG. 18 is a flowchart illustrating a process for streaming and storing A/V content from the device of FIG. 17, according to an embodiment.

FIG. 19 is a functional block diagram of a client device on which the present embodiments may be implemented according to various aspects of the present disclosure.

FIG. 20 is a functional block diagram of a system on which the present embodiments may be implemented according to various aspects of present disclosure.

FIG. 21 is a front perspective view of the device of FIG. 17 implemented as a doorbell, in an embodiment.

FIG. 22 is a schematic diagram illustrating a doorbell system including a doorbell sound output device controller with a switching device including a triac, according to an embodiment.

FIG. 23 is a schematic diagram illustrating a doorbell sound output device controller including filtering circuitry, according to an embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Some modern doorbell switches consume significant electrical power and therefore must be used with a shunt device to achieve proper operation. For example, FIG. 3 illustrates a prior-art doorbell system 300 including a transformer 302, a doorbell switch 304, a mechanical doorbell sound output device 306, and a shunt device 308. A primary winding 310 of the transformer 302 is electrically coupled to an AC electrical power source (not shown), and a secondary winding 312 of the transformer 302 is electrically coupled in series with the doorbell switch 304 and the mechanical doorbell sound output device 306. The doorbell switch 300 includes a switching device 314 and a power supply 316. The switching device 314 is electrically coupled in series with the mechanical doorbell sound output device 306. The switching device 314 is normally open, and closing the switching device 314 enables electrical current to flow through the mechanical doorbell sound output device 306, thereby energizing the mechanical doorbell sound output device 306 and causing it to emit at least one tone. The power supply 316 electrically powers the doorbell switch 304, and the power supply 316 receives input electrical power from the transformer 302 via wiring 318 and the mechanical doorbell sound output device 306.

The shunt device 308 increases electrical power available to the doorbell switch 304. In particular, solenoid DC resistance of the mechanical doorbell sound output device 306 is typically about 8 to 12 ohms. This resistance significantly reduces available voltage and power from the transformer 302 to the doorbell switch 304, and the doorbell switch 304 may consume up to a few watts of power, depending on the operational state of the doorbell switch 304. Consequently, the doorbell switch 304 would likely not receive sufficient electrical power if the shunt device 308 were not present.

The shunt device 308 is electrically coupled in parallel with the mechanical doorbell sound output device 306, and the shunt device 308 includes a normally-closed switching device 320 and a current limiting resistor 322 electrically coupled in series. The shunt device 308 bypasses the mechanical doorbell sound output device 306 when the normally-closed switching device 320 is closed, thereby enabling the doorbell switch 304 to receive a greater voltage magnitude and a greater electrical power magnitude than would otherwise be possible if the shunt device 308 were not present. The shunt device 308 further includes control circuitry (not shown) to detect an increase in current flowing through the shunt device 308 in response to closing of the switching device 314, and the control circuitry causes the switching device 320 to open in response to the detected current increase. Opening the switching device 320 enables nearly all available power from the transformer 302 to be provided to the mechanical doorbell sound output device 306. Thus, the shunt device 308 enables each of the doorbell switch 304 and the mechanical doorbell sound output device 306 to receive sufficient electrical power for proper operation.

However, embodiments described herein include the realization that the doorbell system 300 has a significant negative aspect. In particular, closure of the switching device 314 during activation of the mechanical doorbell sound output device 306 electrically bypasses the power supply 316 of the doorbell switch 304. Consequently, the doorbell switch 304 cannot receive electrical power from the transformer 302 during this time. Thus, if the doorbell switch 304 is to operate continuously, a battery or other energy storage device must be provided to power the doorbell switch 304 while the switching device 314 is closed.

There are many disadvantages to powering the doorbell switch 304 from a battery or other energy storage device. For example, a battery has a limited lifespan, and battery performance is typically significantly reduced at cold temperatures. Indeed, commercial grade, rechargeable LiPo (lithium polymer) batteries are typically not allowed to charge at battery temperatures below 0° C., due to issues of battery damage and lifetime degradation. Doorbell switches are typically mounted outside of a building where weather conditions can easily be such that LiPo battery charging is not recommended. Additionally, presence of a rechargeable battery in the doorbell switch 304 typically requires battery management hardware and/or firmware, thus making the doorbell switch 304 relatively complicated and expensive. Accordingly, a doorbell switch that does not require a battery is advantageous over a doorbell switch that does require a battery.

Embodiments described herein include doorbell sound output device controllers, doorbell switches, and associated systems and methods that at least partially overcome one or more of the problems discussed above. The new doorbell switches include activation circuitry configured to generate an activation signal in response to a user command to activate a doorbell sound output device, and certain embodiments of the doorbell switches are capable of continuously operating without a battery or other energy storage device. The doorbell sound output device controllers include control circuitry configured to control a switching device to enable flow of electrical current between the doorbell sound output device controller and the doorbell sound output device in response to receiving the activation signal.

FIG. 4 illustrates a doorbell system 400 including an embodiment of the present doorbell switches and an embodiment of the present doorbell sound output device controller. The doorbell system 400 includes a transformer 402, a doorbell switch 404, a doorbell sound output device 406, and a doorbell sound output device controller 408 external to the doorbell switch 404. The doorbell sound output device 406 is, for example, a mechanical doorbell sound output device or an electronic doorbell sound output device. A primary winding 410 of the transformer 402 is electrically coupled to an AC electrical power source (not shown), and a secondary winding 412 of the transformer 402 is electrically coupled to the doorbell switch 404 and the doorbell sound output device controller 408 via wiring 414. Each of the doorbell switch 404 and the doorbell sound output device controller 408 are electrically coupled in parallel with the second winding 412 via the wiring 414.

The doorbell switch 404 includes a user input device 416, activation circuitry 418, and power supply circuitry 420. The user input device 416 is configured to receive a user command to activate the doorbell sound output device 406. In certain embodiments, the user input device 416 is a touch-sensitive input device, such as a push-button switch or a capacitive sensing device, which receives a user command to activate the doorbell sound output device 406 by a user

touching the user input device. Additionally, or alternatively, in some embodiments, the user input device **416** is configured to receive a user command to activate the doorbell sound output device **406** by detecting presence of a user in the vicinity of the doorbell switch **404**, such as from image capture of the user, motion of the user, and/or infrared energy emitting by the user.

The activation circuitry **418** is configured to generate an activation signal in response to the user input device **416** receiving the user command to activate the doorbell sound output device **406**. In particular embodiments, the activation circuitry **418** is configured to transmit the activation signal to the doorbell sound output device controller **408** via the wiring **414** electrically coupling the doorbell switch **404** to the doorbell sound output device controller **408**, such as discussed below with respect to FIGS. **5** and **7**. In some other embodiments, the activation circuitry **418** is configured to transmit the activation signal to the doorbell sound output device controller **408** using another technique, such as using radio frequency transmission or optical transmission.

The power supply circuitry **420** is configured to receive input electrical power from the transformer **402** via the wiring **414** electrically coupling the doorbell switch **404** to the doorbell sound output device controller **408** and the transformer **402**. Additionally, the power supply circuitry **420** is configured to electrically power the doorbell switch **404**. In some embodiments, the power supply circuitry **420** includes a switching power converter and/or a linear regulator, while in some other embodiments, the power supply circuitry **420** rectifies and filters AC voltage from secondary winding **412** to provide bulk power to doorbell switch **404**.

The doorbell sound output device controller **408** includes a switching device **422** and control circuitry **424**. The switching device **422** is configured to control flow of electrical power from the transformer **402** to the doorbell sound output device **406**. The switching device **422** includes, for example, a triac, one or more transistors, or an electro-mechanical relay. For example, FIG. **22** illustrates an embodiment of the doorbell system **400** where the switching device **422** includes a triac **2222**. In particular embodiments, the switching device **422** includes two metal oxide semiconductor field effect transistors (MOSFETs) electrically coupled in series such that the respective body diodes of the MOSFETs have opposing orientations, to prevent both body diodes from being simultaneously forward-biased. The control circuitry **424** is configured to receive the activation signal from the doorbell switch **404**, and control the switching device **422** to enable flow of electrical current from the transformer **402** to the doorbell sound output device **406** in response to receiving the activation signal from the doorbell switch **404**. Thus, the doorbell sound output device **406** emits at least one tone in response to the user input device **416** receiving the user command to activate the doorbell sound output device **406**.

FIG. **5** illustrates a doorbell switch **504**, which is one embodiment of the doorbell switch **404**. The doorbell switch **504** includes a user input device **516**, activation circuitry **518**, and power supply circuitry **520**, which are embodiments of the user input device **416**, the activation circuitry **418**, and the power supply circuitry **420**, respectively. The activation circuitry **518** includes a transmitter **526** configured to generate an activation signal in the form of a tone on the wiring **414** electrically coupling the doorbell switch to the doorbell sound output device controller, to transmit the activation signal to the doorbell sound output device controller. In some embodiments, the activation circuitry **518** generates the tone on the wiring **414** as a differential signal,

to promote distinguishing the tone from spurious noise. In some embodiments, the tone generated by the transmitter **526** is a simple tone, e.g., a tone composed of one or more signals of constant frequency and magnitude. In some other embodiments, the tone generated by the transmitter **526** is a modulated tone, such as to facilitate distinguishing the tone from spurious noise and/or to enable the tone to carry information to the doorbell sound output device controller.

The activation circuitry **518** and the power supply circuitry **520** are electrically coupled in parallel with the wiring **414**, such that operation of the activation circuitry **518** does not interfere with operation of the power supply circuitry **520**. Thus, the power supply circuitry **520** is capable of powering the doorbell switch **504** even when the activation circuitry **518** is transmitting an activation signal to the doorbell sound output device controller. Consequently, the doorbell switch **504** can continuously operate without an energy storage device.

FIG. **6** illustrates a doorbell sound output device controller **608**, which is one embodiment of doorbell sound output device controller **408**. The doorbell sound output device controller **608** is capable of use with the doorbell switch **504** of FIG. **5**. The doorbell sound output device controller **608** includes a switching device **622** and control circuitry **624**, which are embodiments of the switching device **422** and the control circuitry **424**, respectively. Control circuitry **624** includes a receiver **628**, a processor **630**, a power supply **632**, and driver circuitry **634**. The receiver **628** is configured to receive the tone generated the doorbell switch **504** via the wiring **414** electrically coupling the doorbell switch **504** to the doorbell sound output device controller **608**. In some embodiments, the processor **630** may comprise a microprocessor, or another type of processor, such as an ASIC (application-specific integrated circuit). In some embodiments, the receiver **628** includes a phase-locked loop configured to detect a signal having the frequency of the tone generated by the doorbell switch **504**. Additionally, in some embodiments, the receiver **628** includes a bandpass filter and a peak detector to facilitate detecting the tone generated by the doorbell switch **504**.

The processor **630** receives detected signals from the receiver **628**, and the processor **630** filters the tone generated by the doorbell switch **504** from other signals received by the control circuitry **624**. Thus, the processor **630** promotes immunity of the control circuitry **624** to spurious noise. In some embodiments, the processor **630** is further configured to amplify and digitize signals detected by the receiver **628**.

The driver circuitry **634** is configured to electrically interface the switching device **622** with the processor **630**. For example, in embodiments where the switching device **622** includes one or more MOSFETs, the driver circuitry **634** is configured to drive the gates of the one or more MOSFETs, to switch the MOSFETs between their conductive and non-conductive states. In particular embodiments, the driver circuitry **634** is configured provide galvanic isolation between the control circuitry **634** and the switching device **622**, such as via optical or magnetic coupling. The processor **630** controls the driver circuitry **634** to cause the switching device **622** to operate in its conductive state in response to the processor **630** detecting the tone generated by the doorbell switch **504**, thereby causing the doorbell sound output device **406** to emit at least one tone.

In some embodiments, the processor **630** is configured to cause the switching device **622** to operate in its conductive state for a fixed duration in response to the control circuitry **624** receiving the tone from the doorbell switch **504**. In some other embodiments, the processor **630** is configured to

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enable adjustment of a duration that the switching device 622 operates in its conductive state in response to the control circuitry 624 receiving the tone from the doorbell switch 504. For example, in a particular embodiment, the processor 630 is configured to receive a configuration command, such as from the doorbell switch 504 or from one or more configuration switches (not shown) in the doorbell sound output device controller 608, to enable adjustment of the duration that the switching device 622 operates in its conductive state in response to the control circuitry 624 receiving the tone from the doorbell switch 504.

The power supply 632 receives electrical power from the transformer 402 via wiring 414, and the power supply 632 is configured to provide electrical power to the control circuitry 624. In some embodiments, the power supply 632 includes a switching power converter and/or a linear regulator, while in some other embodiments, the power supply 632 rectifies and filters AC voltage from secondary winding 412.

The control circuitry 624 could be modified without departing from the scope of the present embodiments. For example, in some alternate embodiments, the processor 630 is replaced with other analog and/or digital circuitry configured to act as filtering circuitry. FIG. 23 illustrates a doorbell sound output device controller similar to the doorbell sound output device controller 608 but where the processor 630 is replaced with filtering circuitry 2330. As another example, in some other alternate embodiments, the processor 630 is omitted and the receiver 628 is directly coupled to the driver circuitry 634.

FIG. 7 illustrates a doorbell switch 704, which is another embodiment of the doorbell switch 404. The doorbell switch 704 includes a user input device 716, activation circuitry 718, and power supply circuitry 720, which are embodiments of the user input device 416, the activation circuitry 418, and the power supply circuitry 420, respectively. The activation circuitry 718 includes perturbation circuitry 728 configured to generate an activation signal on the wiring 414 electrically coupling the doorbell switch to the doorbell sound output device controller by changing electrical current flowing through the wiring, in response to the user input device 716 receiving a command to activate the doorbell sound output device 406.

The perturbation circuitry 728 includes a normally-open perturbation switching device 730 and an impedance device 732 electrically coupled in series across the wiring 414 electrically coupling the doorbell switch 704 to the doorbell sound output device controller. The impedance value of the impedance device 732 is chosen to be sufficiently low to enable detection of the perturbation switching device 730 being closed through an increase in current flowing between the doorbell switch 704 and a doorbell sound output device controller. However, the impedance value of the impedance device 732 should not be so low as to dissipate excessive power when the perturbation switching device 730 is closed. Although the impedance device 732 is illustrated as a single resistor, the impedance device 732 can take other forms, such as a network of resistors and/or one or more complex impedance devices without departing from the scope of the present embodiments. The perturbation circuitry 728 is configured to close the perturbation switching device 730 in response to the user input device 716 receiving a command to activate the doorbell sound output device 406, thereby changing (increasing) the magnitude of the current flowing through the wiring 414 between the doorbell switch 704 the doorbell sound output device controller.

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The activation circuitry 718 and the power supply 720 are electrically coupled in parallel with the wiring 414, and an impedance value of the impedance device 732 is sufficiently high such that closing of the perturbation switching device 730 does not degrade operation of the power supply circuitry 720. Consequently, operation of the activation circuitry 718 does not interfere with operation of the power supply circuitry 720, and the power supply circuitry 720 is capable of powering the doorbell switch 704 even while the activation circuitry 718 is transmitting an activation signal to a doorbell sound output device controller. Consequently, the doorbell switch 704 can continuously operate without an energy storage device.

FIG. 8 illustrates a doorbell sound output device controller 808, which is another embodiment of the doorbell sound output device controller 408. The doorbell sound output device controller 808 is capable of use with the doorbell switch 704 of FIG. 7. The doorbell sound output device controller 808 includes a switching device 822 and control circuitry 824, which are embodiments of the switching device 422 and the control circuitry 424, respectively. The control circuitry 824 includes current sense circuitry 828, a conditioner 830, a processor 832, driver circuitry 834, and a power supply 836. In some embodiments, the processor 832 may comprise a microprocessor, or another type of processor, such as an ASIC (application-specific integrated circuit).

The current sensing circuitry 828 is configured to receive the activation signal from the doorbell switch 704 via a change in electrical current flowing between the doorbell sound output device control 808 and the doorbell switch 704. In the illustrated embodiment, current sense circuitry 828 includes an electrical conductor 838 and a Hall effect sensor 840. The electrical conductor 838 is configured to be electrically coupled to the doorbell switch 704 such that electrical current flowing between the doorbell switch 704 and the doorbell sound output device controller 808 flows through the electrical conductor 838. Therefore, electrical current flowing through the electrical conductor 838 represents the electrical current flowing between the doorbell switch 704 and the doorbell sound output device controller 808. In certain embodiments, the electrical conductor 838 forms a small number of turns, such as only a single turn, to minimize length and associated resistance of the electrical conductor 838. The Hall effect sensor 840 is configured to sense a magnetic field generated by electrical current flowing through the electrical conductor 838 and generate a correspond signal.

The use of the electrical conductor 838 and the Hall effect sensor 840 to detect the activation signal generated by the doorbell switch 704 has advantages. For example, the electrical conductor 838 can be embodied as a single loop of copper wire or metal film integrated within the package of an integrated circuit (IC), to promote low cost, low voltage drop across the current sensing circuitry 828, and/or ease of manufacturing the current sensing circuitry. Additionally, the magnetic coupling between electrical conductor 838 and the Hall effect sensor 840 may provide galvanic isolation between DC-powered components of the control circuitry 824 and AC powered circuitry.

The conditioner 830 conditions the signal generated by the Hall effect sensor 840 to a form that is compatible with the processor 832. For example, in some embodiments, the conditioner 830 sufficiently amplifies the signal generated by the Hall effect sensor 840 so that the signal is detectable by the processor 832. In some embodiments, the processor 832 is further configured to amplify and digitize signals detected by the conditioner 830. The processor 832 is

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configured to detect the change in electrical current flowing between the doorbell sound output device controller **808** and the doorbell switch **704**, which represents the activation signal, from the conditioned signal via generated by the conditioner **830**.

For instance, in some embodiments, the processor **832** is configured to detect the activation signal in response to a change in amount of time that magnitude of the electrical current flowing through the electrical conductor **838** is zero, which is equivalent to a change in amount of time that the magnitude of the electrical current flowing between the doorbell sound output device controller **808** and the doorbell switch **704** is zero. To help appreciate how magnitude of electrical current can be changed by the perturbation circuitry **728**, consider the examples of FIGS. **9** and **10**. FIG. **9** is an example graph of magnitude of current through the electrical conductor **838** versus time when the switching device **730** is open, and FIG. **10** is an example graph of current through the electrical conductor **838** versus time when the switching device **730** is closed. As illustrated in FIG. **9**, magnitude of current through the electrical conductor **838** is zero more than 50% of the time when the switching device **730** is open, e.g., when the activation circuitry **718** is not generating an activation signal. In contrast, when the switching device **730** is closed, e.g., when the activation circuitry **718** is generating an activation signal, magnitude of current through the electrical conductor **838** is zero only twice per cycle of AC voltage across the wiring **414**. The processor **832** detects such decrease in amount of time that magnitude of current through the electrical conductor **838** is zero as an activation signal from the doorbell switch **704**.

The small magnitude of current through the impedance device **732** relative to the scale of the FIG. **10** graph causes portions of the FIG. **10** graph to appear linear. Such portions of the graph are actually sinusoidal, but such sinusoidal characteristic is not perceptible in the FIG. **10** graph.

The driver circuitry **834** is configured to interface the switching device **822** with the processor **832** in a manner analogous to that of the driver circuitry **634** of FIG. **6**. The processor **832** controls the driver circuitry **834** to cause the switching device **822** to operate in its conductive state in response to the processor **832** detecting the activation signal generated by the doorbell switch **704** from a change in electrical current flowing through the electrical conductor **838**, thereby causing the doorbell sound output device **406** to emit at least one tone.

In some embodiments, the processor **832** is configured to cause the switching device **822** to operate in its conductive state for a fixed duration in response to the control circuitry **824** receiving an activation signal from doorbell switch **704**. In some other embodiments, the processor **832** is configured to enable adjustment of a duration that the switching device **822** operates in its conductive state in response to the control circuitry **824** receiving the activation signal from the doorbell switch **704**. For example, in a particular embodiment, the processor **832** is configured to receive a configuration command, such as from the doorbell switch **704** or from one or more configuration switches (not shown) in the doorbell sound output device controller **808**, to enable adjustment of the duration that the switching device **822** operates in its conductive state in response to the control circuitry **824** receiving the activation signal from the doorbell switch **704**.

The power supply **836** receives electrical power from the transformer **402** via the wiring **414**, and the power supply **836** is configured to provide electrical power to the control circuitry **824**. In some embodiments, the power supply **832**

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includes a switching power converter and/or a linear regulator, while in some other embodiments, the power supply **832** rectifies and filters AC voltage from the secondary winding **412**.

The control circuitry **824** could be modified without departing from the scope of the present embodiments. For example, in some alternate embodiments, the processor **832** is replaced with other analog and/or digital circuitry configured to act as filtering circuitry. As another example, in some other alternate embodiments, the processor **832** is omitted and the conditioner **830** is directly coupled to the driver circuitry **834**. As another example, in certain alternate embodiments, the current sense circuitry **828** is implemented in a different manner than that illustrated in FIG. **8**, such as by use of a current sense resistor in place of the electrical conductor **838** and the Hall effect sensor **840**.

The doorbell sound output device controllers herein could be configured to support an electronic doorbell sound output device. For example, FIG. **11** illustrates a doorbell system **1100**, which is similar to the doorbell system **400** of FIG. **4**, but where the doorbell sound output device controller **408** is replaced with a doorbell sound output device controller **1108**. The doorbell sound output device controller **1108** is similar to the doorbell sound output device controller **408**, but further includes a diode device **1126** electrically coupled in parallel with the switching device **422**. The diode device **1126** provides a path for DC electrical current between the doorbell sound output device controller **1108** and the doorbell sound output device **406**, such as in cases where the doorbell sound output device **406** is an electronic doorbell sound output device. The polarity of the diode device **1126**, e.g., the locations of its anode (A) and cathode (K) with respect to other components of the doorbell sound output device controller **1108**, could be reversed without departing from the scope of the present embodiments.

In some embodiments, the diode device **1126** is implemented by a single semiconductor diode, such as illustrated in FIG. **11**. In some other embodiments, the diode device **1126** is implemented by multiple semiconductor diodes electrically coupled in series, such as to achieve a high breakdown voltage rating. In yet some other embodiments, the diode device **1126** is implemented by one or more transistors, or by body diodes of one or more transistors.

For example, FIG. **12** illustrates a doorbell system **1200**, which is an embodiment of the doorbell system **1100** where the doorbell sound output device controller **1108** is implemented as a doorbell sound output device controller **1208**. The switching device **422** of the doorbell sound output device controller **1108** is implemented by two n-channel, enhancement MOSFETs **1222** and **1223** electrically coupled in series with opposing orientations, in the doorbell sound output device controller **1208**. The control circuitry **424** drives the gates of the MOSFETs **1222** and **1223** to switch the MOSFETs between their respective conductive and non-conductive states to control flow of electrical current between the doorbell sound output device controller **1208** and the doorbell sound output device **406**. The control circuitry **424** is further configured to receive a configuration command, such as from the doorbell switch **404** or from configuration switches (not shown) in the doorbell sound output device controller **1208**, to configure the doorbell sound output device controller **1208** for use with an electronic doorbell sound output device. In particular, the control circuitry **424** causes the MOSFET **1223** to continuously operate in its conductive state in response to the configuration command, such that a body diode **1226** of the MOSFET

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1222 provides a path for direct current between the doorbell sound output device controller **1208** and the doorbell sound output device **406**.

The configurations of the transistors in doorbell sound output device controller **1208** could be varied with departing from the scope of the present embodiments. For example, the MOSFETs **1222** and **1223** could be replaced with p-channel MOSFETs with appropriate changes to the control circuitry **424**.

Although the doorbell switches **404**, **504**, and **704** are illustrated as including only a user input device, activation circuitry, and power supply circuitry for illustrative simplicity, any of these doorbell switches could include additional components without departing from the scope of the present embodiments. For example, FIG. **13** illustrates a doorbell switch **1300**, which is an embodiment of the doorbell switch **404** configured as a video doorbell. The doorbell switch **1300** represents an audio/video (A/V) recording and communication device (also referred to as a security device). The doorbell switch **1300** includes power management circuitry **1302**, an audio coder-decoder (codec) **1304**, a modem **1306**, a processor **1308**, a memory **1310** communicatively coupled to the processor **1308**, a video camera **1312**, a microphone **1314**, and a speaker **1316**, as well as an instance of the user input device **416**, the activation circuitry **418**, and the power supply circuitry **420**. The power management circuitry **1302** receives bulk power from the power supply circuitry **420** and conditions the bulk power for use by the doorbell switch **1300**. For example, in some embodiments, the power management circuitry **1302** regulates bulk power from the power supply circuitry **420**. Electrical power from the power management circuitry **1302** is distributed to other components of the doorbell switch **1300** via an electrical bus **1318**. The power management circuitry **1302** may be omitted in cases where bulk power from the power supply circuitry **420** is sufficiently regulated for use within the doorbell switch **1300**.

The modem **1306** is configured to enable the doorbell switch **1300** to communicate with an external system. For example, in some embodiments, the modem **1306** is a wireless modem, such as for use with a WiFi network. As another example, in some other embodiments, the modem **1306** is configured for use with an optical network or a wired network. Communications via the modem **1306** may also include links to any of a variety of wireless networks, including WAP (Wireless Application Protocol), GPRS (General Packet Radio Service), GSM (Global System for Mobile Communication), LTE, VoLTE, LoRaWAN, LPWAN, RPMA, LTE Cat-“X” (e.g., LTE Cat 1, LTE Cat 0, LTE CatM1, LTE Cat NB1), CDMA (Code Division Multiple Access), TDMA (Time Division Multiple Access), FDMA (Frequency Division Multiple Access), and/or OFDMA (Orthogonal Frequency Division Multiple Access) cellular phone networks, GPS, CDPD (cellular digital packet data), RIM (Research in Motion, Limited) duplex paging network, Bluetooth radio, or an IEEE 802.11-based radio frequency network. The modem **1306** may further include or interface with any one or more of the following: RS-232 serial connection, IEEE-1394 (Firewire) connection, Fibre Channel connection, IrDA (infrared) port, SCSI (Small Computer Systems Interface) connection, USB (Universal Serial Bus) connection, or other wired or wireless, digital or analog, interface or connection, mesh or Digi® networking.

The video camera **1312** is configured to generate video image data representing a scene proximate to the doorbell switch **1300**. In particular embodiments, the video camera **1312** includes a complementary metal oxide semiconductor

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(CMOS) image sensor and supporting circuitry. The video camera **1312** in some embodiments may include an infrared light source and a selectively-activated infrared filter, to facilitate generating video image data in both light and dark ambient conditions.

The audio codec **1304** is configured to interface the microphone **1312** and the speaker **1314**, which are each analog devices, with digital circuitry in the doorbell switch **1300**, such with the processor **1308**. Accordingly, the audio codec **1304** is configured to convert data between digital form and analog form, and vice versa. The microphone **1314** is configured to generate sound data representing sound proximate to the doorbell switch **1300**, and the speaker **1316** is configured to generate sound data representing sound in response to a signal received by the doorbell switch **1300** from a device external to the doorbell switch **1300**.

The processor **1308** is configured to execute instructions in the form of software and/or firmware stored in the memory **1310** to control operation of the doorbell switch **1300**. For example, in some embodiments, the processor **1308** is configured to enable a remote user to view a scene proximate to the doorbell switch **1300** via the video camera **1312** and the modem **1306**. As another example, in certain embodiments, the processor **1308** is configured to enable a remote user to listen to sound proximate to the doorbell switch **1300** via the microphone **1314**, the audio code **1304**, and the modem **1306**. As yet another example, in particular embodiments, the processor **1308** is configured to enable a remote user to make an audio announcement at the doorbell switch **1300** via the speaker **1316**, the audio codec **1304**, and the modem **1306**.

Any of the doorbell switches **404**, **504**, and **704** could be integrated with a doorbell sound output device without departing from the scope of the present embodiments. For example, FIG. **14** illustrates a doorbell system **1400**, which is similar to the doorbell system **400** of FIG. **4**, but where the doorbell sound output device **406** and the doorbell sound output device controller **408** are integrated in a common package **1402**. Additionally, the transformer **402** could be co-packaged the doorbell sound output device and the doorbell sound output device controller. For example, FIG. **15** illustrates a doorbell system **1500**, which is similar to the doorbell system **400** of FIG. **4**, but where the doorbell sound output device **406**, the doorbell sound output device controller **408**, and the transformer **402** are integrated in a common package **1502**.

FIG. **16** illustrates a method **1600** for operating a doorbell sound output device in accordance with various aspects of the present embodiments. At block **1602**, an activation signal is generated at a doorbell switch in response a user command to activate the doorbell sound output device. In one example of block **1602**, the transmitter **526** (FIG. **5**) generates a tone on the wiring **414** in response to the user input device **516** receiving a user command to activate doorbell sound output device **406**. In another example of block **1602**, the perturbation switching device **730** (FIG. **7**) closes in response to the user input device **716** receiving a user command to activate the doorbell sound output device **406**.

At block **1604**, the activation signal is received at a doorbell sound output device controller external to the doorbell switch. In one example of block **1604**, the receiver **628** (FIG. **6**) receives the activation signal via a tone from the doorbell switch **504**. In another example of block **1604**, the current sensing circuitry **828** (FIG. **8**) receives the activation signal from the doorbell switch **704** via a change

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in electrical current flowing between the doorbell sound output device controller **808** and the doorbell switch **704**.

At block **1606**, flow of electrical current between the doorbell sound output device controller and the doorbell sound output device is enabled in response to receiving the activation signal at the doorbell sound output device controller. In one example of block **1606**, the processor **630** (FIG. **6**) controls the driver circuitry **634** to cause the switching device **622** to operate in its conductive state in response to the receiver **628** receiving an activation signal via a tone from the doorbell switch **504**. As another example of block **1606**, the processor **832** (FIG. **8**) controls the driver circuitry **834** to cause the switching device **822** to operate in its conductive state in response to the current sensing circuitry **828** receiving the activation signal from the doorbell switch **704** via a change in electrical current flowing between the doorbell sound output device controller **808** and the doorbell switch **704**.

A/V Recording and Communication Device

With reference to FIG. **17**, the present embodiments include an A/V recording and communication device **1700**, also known as a security device **1700**. The A/V recording and communication device **1700** is an embodiment of the doorbell switches **404**, **504**, **704**, and **1300**, discussed above. An example A/V recording and communication security camera may include substantially all of the structure and/or functionality of the doorbells described herein, but without a front button and related components.

The A/V recording and communication device **1700** may be located near the entrance to a structure (not shown), such as a dwelling, a business, a storage facility, etc. The A/V recording and communication device **1700** includes a camera **1702**, a microphone **1704**, and a speaker **1706**. The camera **1702** may include, for example, a high definition (HD) video camera, such as one configured for capturing video images at an image display resolution of 720p, or 1080p, or better. The camera **1702** may be an embodiment of the video camera **1312** discussed above. While not shown, the A/V recording and communication device **1700** may also include other hardware and/or components, such as a housing, a communication module (e.g., the modem **1306** discussed above, which may facilitate wired and/or wireless communication with other devices), one or more motion sensors (and/or other types of sensors), a button, etc. The A/V recording and communication device **1700** may further include similar componentry and/or functionality as the wireless communication doorbells described in U.S. Pat. No. 9,584,775 and U.S. patent application Ser. No. 2015/0022618 (application Ser. No. 14/334,922), respectively.

With further reference to FIG. **17**, the A/V recording and communication device **1700** communicates with a user's network **1710**, which may be for example a wired and/or wireless network. If the user's network **1710** is wireless, or includes a wireless component, the network **1710** may be a Wi-Fi network compatible with the IEEE 802.11 standard and/or other wireless communication standard(s). The user's network **1710** is connected to another network **1712**, which may include, for example, the Internet and/or a public switched telephone network (PSTN). As described below, the A/V recording and communication device **1700** may communicate with the user's client device **1714** via the user's network **1710** and the network **1712** (Internet/PSTN). Alternatively, the A/V recording and communication device **1700** may communicate with the user's client device **1714** via the user's network **1710** (without the network **1712**)

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and/or via a direct connection, such as over a short-range protocol connection (e.g., Bluetooth, BTLE, etc.) The user's client device **1714** may include, for example, a mobile telephone (may also be referred to as a cellular telephone), such as a smartphone, a personal digital assistant (PDA), or another communication device. The user's client device **1714** includes a display (not shown) and related components configured for displaying streaming and/or recorded video images. The user's client device **1714** may also include a speaker and related components configured for broadcasting streaming and/or recorded audio, and may also include a microphone. The A/V recording and communication device **1700** may also communicate with one or more remote storage device(s) **1716** (may be referred to interchangeably as "cloud storage device(s)"), one or more servers **1718**, and/or a backend API (application programming interface) **1720** via the user's network **1710** and the network **1712** (Internet/PSTN). While FIG. **17** illustrates the storage device **1716**, the server **1718**, and the backend API **1720** as components separate from the network **1712**, it is to be understood that the storage device **1716**, the server **1718**, and/or the backend API **1720** may be considered to be components of the network **1712**.

The network **1712** may be any wireless network or any wired network, or a combination thereof, configured to operatively couple the above-mentioned modules, devices, and systems as shown in FIG. **17**. For example, the network **1712** may include one or more of the following: a PSTN, the Internet, a local intranet, a PAN (Personal Area Network), a LAN (Local Area Network), a WAN (Wide Area Network), a MAN (Metropolitan Area Network), a virtual private network (VPN), a storage area network (SAN), a frame relay connection, an Advanced Intelligent Network (AIN) connection, a synchronous optical network (SONET) connection, a digital T1, T3, E1 or E3 line, a Digital Data Service (DDS) connection, a DSL (Digital Subscriber Line) connection, an Ethernet connection, an ISDN (Integrated Services Digital Network) line, a dial-up port such as a V.90, V.34, or V.34bis analog modem connection, a cable modem, an ATM (Asynchronous Transfer Mode) connection, or an FDDI (Fiber Distributed Data Interface) or CDDI (Copper Distributed Data Interface) connection. Furthermore, communications may also include links to any of a variety of wireless networks, including WAP (Wireless Application Protocol), GPRS (General Packet Radio Service), GSM (Global System for Mobile Communication), LTE, VoLTE, LoRaWAN, LPWAN, RPMA, LTE Cat-"X" (e.g., LTE Cat 1, LTE Cat 0, LTE CatM1, LTE Cat NB1), CDMA (Code Division Multiple Access), TDMA (Time Division Multiple Access), FDMA (Frequency Division Multiple Access), and/or OFDMA (Orthogonal Frequency Division Multiple Access) cellular phone networks, GPS, CDPD (cellular digital packet data), RIM (Research in Motion, Limited) duplex paging network, Bluetooth radio, or an IEEE 802.11-based radio frequency network. The network **1712** may further include or interface with any one or more of the following: RS-232 serial connection, IEEE-1394 (Firewire) connection, Fibre Channel connection, IrDA (infrared) port, SCSI (Small Computer Systems Interface) connection, USB (Universal Serial Bus) connection, or other wired or wireless, digital or analog, interface or connection, mesh or Digi® networking.

In certain embodiments, when a person (may be referred to interchangeably as "visitor") arrives at the A/V recording and communication device **1700**, the A/V recording and communication device **1700** detects the visitor's presence and begins capturing video images within a field of view of

camera **1702**. The A/V recording and communication device **1700** may also capture audio through microphone **1704**. The A/V recording and communication device **1700** may detect the visitor's presence by detecting motion using the camera **1702** and/or a motion sensor, and/or by detecting that the visitor has pressed a front button of the A/V recording and communication device **1700** (for example, when the A/V recording and communication device **1700** is a doorbell).

In response to the detection of the visitor, the A/V recording and communication device **1700** sends an alert to the user's client device **1714** (FIG. **17**) via the user's network **1710** and the network **1712**. The A/V recording and communication device **1700** also sends streaming video, and may also send streaming audio, to the user's client device **1714**. If the user answers the alert, two-way audio communication may then occur between the visitor and the user through the A/V recording and communication device **1700** and the user's client device **1714**. The user may view the visitor throughout the duration of the call, but the visitor cannot see the user (unless the A/V recording and communication device **1700** includes a display, which it may in certain embodiments).

The video images captured by the camera **1702** of the A/V recording and communication device **1700** (and the audio captured by the microphone **1704**) may be uploaded to the cloud and recorded on the remote storage device **1716** (FIG. **17**). In some embodiments, the video and/or audio may be recorded on the remote storage device **1716** even if the user chooses to ignore the alert sent to the user's client device **1714**.

With further reference to FIG. **17**, the system may further include a backend API **1720** including one or more components. A backend API (application programming interface) may include, for example, a server (e.g., a real server, or a virtual machine, or a machine running in a cloud infrastructure as a service), or multiple servers networked together, exposing at least one API to client(s) accessing it. These servers may include components such as application servers (e.g., software servers), depending upon what other components are included, such as a caching layer, or database layers, or other components. A backend API may, for example, include many such applications, each of which communicate with one another using their public APIs. In some embodiments, the API backend may hold the bulk of the user data and offer the user management capabilities, leaving the clients to have very limited state.

The backend API **1720** may include one or more APIs. An API is a set of routines, protocols, and tools for building software and applications. An API expresses a software component in terms of its operations, inputs, outputs, and underlying types, defining functionalities that are independent of their respective implementations, which allows definitions and implementations to vary without compromising the interface. Advantageously, an API may provide a programmer with access to an application's functionality without the programmer needing to modify the application itself, or even understand how the application works. An API may be for a web-based system, an operating system, or a database system, and it provides facilities to develop applications for that system using a given programming language. In addition to accessing databases or computer hardware like hard disk drives or video cards, an API can ease the work of programming GUI components. For example, an API can facilitate integration of new features into existing applications (a so-called "plug-in API"). An API can also

assist otherwise distinct applications with sharing data, which can help to integrate and enhance the functionalities of the applications.

The backend API **1720** may further include one or more services (also referred to as network services). A network service is an application that provides data storage, manipulation, presentation, communication, and/or other capability. Network services are often implemented using a client-server architecture based on application-layer network protocols. Each service may be provided by a server component running on one or more computers (such as a dedicated server computer offering multiple services) and accessed via a network by client components running on other devices. However, the client and server components can both be run on the same machine. Clients and servers may have a user interface, and sometimes other hardware associated with them.

The A/V recording device **1700** may include any of the features discussed above with respect to doorbell switches **404**, **504**, **704**, and **1300** to manage power and control of the doorbell sound output device **406**.

FIG. **18** is a flowchart illustrating a process **1800** for streaming and storing A/V content from the A/V recording and communication device **1700**, in an embodiment. At block **1801**, the A/V recording and communication device **1700** detects the visitor's presence and captures video images within a field of view of the camera **1702**. The A/V recording and communication device **1700** may also capture audio through the microphone **1704**. As described above, the A/V recording and communication device **1700** may detect the visitor's presence by detecting motion using the camera **1702** and/or a motion sensor, and/or by detecting that the visitor has pressed a front button of the A/V recording and communication device **1700** (for example, when the A/V recording and communication device **1700** is a doorbell). Also as described above, the video recording/capture may begin when the visitor is detected, or may begin earlier, as described below.

At block **1802**, a communication module of the A/V recording and communication device **1700** sends a connection request, via the user's network **1710** and the network **1712**, to a device in the network **1712**. For example, the network device to which the connection request is sent may be a server such as the server **1718**. The server **1718** may include a computer program and/or a machine that waits for requests from other machines or software (clients) and responds to them. A server typically processes data. One purpose of a server is to share data and/or hardware and/or software resources among clients. This architecture is called the client-server model. The clients may run on the same computer or may connect to the server over a network. Examples of computing servers include database servers, file servers, mail servers, print servers, web servers, game servers, and application servers. The term server may be construed broadly to include any computerized process that shares a resource to one or more client processes. In another example, the network device to which the request is sent may be an API such as the backend API **1720**, which is described above.

In response to the request, at block **1804** the network device may connect the A/V recording and communication device **1700** to the user's client device **1714** through the user's network **1710** and the network **1712**. At block **1806**, the A/V recording and communication device **1700** may record available audio and/or video data using the camera **1702**, the microphone **1704**, and/or any other device/sensor available. At block **1808**, the audio and/or video data is

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transmitted (streamed) from the A/V recording and communication device **1700** to the user's client device **1714** via the user's network **1710** and the network **1712**. At block **1810**, the user may receive a notification on the user's client device **1714** with a prompt to either accept or deny the call.

At block **1812**, the process **1800** determines whether the user has accepted or denied the call. If the user denies the notification, then the process **1800** advances to block **1814**, where the audio and/or video data is recorded and stored at a cloud server. The session then ends at block **1816** and the connection between the A/V recording and communication device **1700** and the user's client device **1714** is terminated. If, however, the user accepts the notification, the process **1800** proceeds with block **1818** where the user communicates with the visitor through the user's client device **1714** while audio and/or video data captured by the camera **1702**, the microphone **1704**, and/or other devices/sensors, is streamed to the user's client device **1714**. At the end of the call, the user may terminate the connection between the user's client device **1714** and the A/V recording and communication device **1700** and the session ends at block **1816**. In some embodiments, the audio and/or video data may be recorded and stored at a cloud server (block **1814**) even if the user accepts the notification and communicates with the visitor through the user's client device **1714**.

FIG. **19** is a functional block diagram of a client device **1900** on which the present embodiments may be implemented according to various aspects of the present disclosure. The user's client device **1714** described with reference to FIG. **17** may include some or all of the components and/or functionality of the client device **1900**. The client device **1900** may be, for example, a smartphone.

The client device **1900** includes a processor **1902**, a memory **1904**, a user interface **1906**, a communication module **1908**, and a dataport **1910**. These components are communicatively coupled together by an interconnect bus **1912**. The processor **1902** may include any processor used in smartphones and/or portable computing devices, such as an ARM processor (a processor based on the RISC (reduced instruction set computer) architecture developed by Advanced RISC Machines (ARM)). In certain embodiments, the processor **1902** includes one or more other processors, such as one or more microprocessors, and/or one or more supplementary co-processors, such as math co-processors.

The memory **1904** may include both operating memory, such as random access memory (RAM), as well as data storage, such as read-only memory (ROM), hard drives, flash memory, or any other suitable memory/storage element. The memory **1904** may include removable memory elements, such as a CompactFlash card, a MultiMediaCard (MMC), and/or a Secure Digital (SD) card. In certain embodiments, the memory **1904** includes a combination of magnetic, optical, and/or semiconductor memory, and may include, for example, RAM, ROM, flash drive, and/or a hard disk or drive. The processor **1902** and the memory **1904** each may be located entirely within a single device, or may be connected to each other by a communication medium, such as a USB port, a serial port cable, a coaxial cable, an Ethernet-type cable, a telephone line, a radio frequency transceiver, or other similar wireless or wired medium or combination of the foregoing. For example, the processor **1902** may be connected to the memory **1904** via the dataport **1910**.

The user interface **1906** may include any user interface or presentation elements suitable for a smartphone and/or a portable computing device, such as a keypad, a display

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screen, a touchscreen, a microphone, and a speaker. The communication module **1908** is configured to handle communication links between the client device **1900** and other, external devices or receivers, and to route incoming/outgoing data appropriately. For example, inbound data from the dataport **1910** may be routed through the communication module **1908** before being directed to the processor **1902**, and outbound data from the processor **1902** may be routed through the communication module **1908** before being directed to the dataport **1910**. The communication module **1908** may include one or more transceiver modules configured for transmitting and receiving data, and using, for example, one or more protocols and/or technologies, such as GSM, UMTS (3GSM), IS-95 (CDMA one), IS-2000 (CDMA 2000), LTE, FDMA, TDMA, W-CDMA, CDMA, OFDMA, Wi-Fi, WiMAX, or any other protocol and/or technology.

The dataport **1910** may be any type of connector used for physically interfacing with a smartphone and/or a portable computing device, such as a mini-USB port or an IPHONE®/IPOD® 30-pin connector or LIGHTNING® connector. In other embodiments, the dataport **1910** may include multiple communication channels for simultaneous communication with, for example, other processors, servers, and/or client terminals.

The memory **1904** may store instructions for communicating with other systems, such as a computer. The memory **1904** may store, for example, a program (e.g., computer program code) adapted to direct the processor **1902** in accordance with the present embodiments. The instructions also may include program elements, such as an operating system. While execution of sequences of instructions in the program causes the processor **1902** to perform the process steps described herein, hard-wired circuitry may be used in place of, or in combination with, software/firmware instructions for implementation of the processes of the present embodiments. Thus, the present embodiments are not limited to any specific combination of hardware and software.

System/Device

FIG. **20** is a functional block diagram of a system **2000** on which the present embodiments may be implemented according to various aspects of the present disclosure. For example, aspects of the system **2000** may be an example of the doorbell switch **404**, **504**, **704**, and **1300**, the doorbell sound output device controller **408**, **608**, **808**, **1108**, and **1208**, and the A/V recording and communication device **1700**. The computer system **2000** may be embodied in at least one of a personal computer (also referred to as a desktop computer) **2002**, a portable computer (also referred to as a laptop or notebook computer) **2004**, and/or a server **2006**. A server is a computer program and/or a machine that waits for requests from other machines or software (clients) and responds to them. A server typically processes data. The purpose of a server is to share data and/or hardware and/or software resources among clients. This architecture is called the client-server model. The clients may run on the same computer or may connect to the server over a network. Examples of computing servers include database servers, file servers, mail servers, print servers, web servers, game servers, and application servers. The term server may be construed broadly to include any computerized process that shares a resource to one or more client processes.

The computer system **2000** may execute at least some of the operations described above. The computer system **2000** may include at least one processor **2010**, a memory **2020**, at

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least one storage device **2030**, and input/output (I/O) devices **2040**. Some or all of the components **2010**, **2020**, **2030**, **2040** may be interconnected via a system bus **2050**. The processor **2010** may be single- or multi-threaded and may have one or more cores. The processor **2010** may execute instructions, such as those stored in the memory **2020** and/or in the storage device **2030**. Information may be received and output using one or more of the I/O devices **2040**.

The memory **2020** may store information, and may be a computer-readable medium, such as volatile or non-volatile memory. The storage device(s) **2030** may provide storage for the computer system **2000**, and may be a computer-readable medium. In various embodiments, the storage device(s) **2030** may be one or more of a flash memory device, a hard disk device, an optical disk device, a tape device, or any other type of storage device.

The I/O devices **2040** may provide input/output operations for the computer system **2000**. The I/O devices **2040** may include a keyboard, a pointing device, and/or a microphone. The I/O devices **2040** may further include a display unit for displaying graphical user interfaces, a speaker, and/or a printer. External data may be stored in one or more accessible external databases **2060**.

The features of the present embodiments described herein may be implemented in digital electronic circuitry, and/or in computer hardware, firmware, software, and/or in combinations thereof. Features of the present embodiments may be implemented in a computer program product tangibly embodied in an information carrier, such as a machine-readable storage device, and/or in a propagated signal, for execution by a programmable processor. Embodiments of the present method steps may be performed by a programmable processor executing a program of instructions to perform functions of the described implementations by operating on input data and generating output.

The features of the present embodiments described herein may be implemented in one or more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and/or instructions from, and to transmit data and/or instructions to, a data storage system, at least one input device, and at least one output device. A computer program may include a set of instructions that may be used, directly or indirectly, in a computer to perform a certain activity or bring about a certain result. A computer program may be written in any form of programming language, including compiled or interpreted languages, and it may be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment.

Suitable processors for the execution of a program of instructions may include, for example, both general and special purpose processors, and/or the sole processor or one of multiple processors of any kind of computer. Generally, a processor may receive instructions and/or data from a read only memory (ROM), or a random access memory (RAM), or both. Such a computer may include a processor for executing instructions and one or more memories for storing instructions and/or data.

Generally, a computer may also include, or be operatively coupled to communicate with, one or more mass storage devices for storing data files. Such devices include magnetic disks, such as internal hard disks and/or removable disks, magneto-optical disks, and/or optical disks. Storage devices suitable for tangibly embodying computer program instructions and/or data may include all forms of non-volatile memory, including for example semiconductor memory

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devices, such as EPROM, EEPROM, and flash memory devices, magnetic disks such as internal hard disks and removable disks, magneto-optical disks, and CD-ROM and DVD-ROM disks. The processor and the memory may be supplemented by, or incorporated in, one or more ASICs (application-specific integrated circuits).

To provide for interaction with a user, the features of the present embodiments may be implemented on a computer having a display device, such as an LCD (liquid crystal display) monitor, for displaying information to the user. The computer may further include a keyboard, a pointing device, such as a mouse or a trackball, and/or a touchscreen by which the user may provide input to the computer.

The features of the present embodiments may be implemented in a computer system that includes a back-end component, such as a data server, and/or that includes a middleware component, such as an application server or an Internet server, and/or that includes a front-end component, such as a client computer having a graphical user interface (GUI) and/or an Internet browser, or any combination of these. The components of the system may be connected by any form or medium of digital data communication, such as a communication network. Examples of communication networks may include, for example, a LAN (local area network), a WAN (wide area network), and/or the computers and networks forming the Internet.

The computer system may include clients and servers. A client and server may be remote from each other and interact through a network, such as those described herein. The relationship of client and server may arise by virtue of computer programs running on the respective computers and having a client-server relationship to each other.

Example Embodiments

FIG. **21** is a front perspective view of a doorbell **2130** that represents one example implementation of the security device **1700** of FIG. **17** and the above discussed doorbell switches **404**, **504**, **704**, and **1300**, hereafter referred to as device **2130**. The device **2130** has a housing **2131** that includes a backplate **2139**, a faceplate **2135** with a button **2133**, an optically-transparent lens **2134A** positioned in front of a camera **2134**, and an infrared-transparent lens **2132A** positioned in front of at least one motion sensor **2132**. The housing **2131** may be further configured with an aperture **2181** to allow sound to enter the housing **2131** for detection by a microphone. The device **2130** may also include a mounting bracket **2142** that couples with the backplate **2139** to facilitate mounting of the device **2130** on a flat surface, such as the exterior of a building, such as a home or office. For example, the mounting bracket **2142** may be selected for mounting to surfaces of various composition, including, without limitation, wood, concrete, stucco, brick, vinyl siding, aluminum siding, etc., with any suitable fasteners, such as screws, or interference connections, adhesives, etc. The device **2130** may couple to the mounting bracket **2142** using any suitable fasteners, such as screws, or interference connections, mating hooks and apertures, adhesives, etc. The backplate **2139** may include screw terminals configured to receive electrical wires adjacent a mounting surface of the device **2130**. The device **2130** may receive electrical power through the screw terminals and/or the device **2130** may control electrical connectivity of the screw terminals to cause a conventional doorbell to sound if so connected to the wires.

The faceplate **2135** may extend from the bottom of the device **2130** up to just below the camera **2134**. The faceplate

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2135 may be formed of any suitable material, including, without limitation, metals, such as brushed aluminum or stainless steel, metal alloys, and plastics, and any combination thereof. The faceplate **2135** protects the internal contents of the device **2130** and serves as an exterior front surface of the device **2130**. The faceplate **2135** may include an aperture **2136A** with a flexible translucent membrane **2136** for movably holding the button **2133**. The faceplate **2135** is also formed with at least one speaker grille **2180** to allow sound generated within the housing **2131** to exit. The button **2133** and the flexible translucent membrane **2136** may have various profiles that may or may not match the profile of the faceplate **2135**. The flexible translucent membrane **2136** may include any suitable material, including, without limitation, a transparent silicone, plastic, or rubber, that is configured for allowing light produced within the device **2130** to pass through and is sufficiently flexible to allow the button **2133** to be pressed. The light may be produced by one or more light-emitting components, such as light-emitting diodes (LEDs), contained within the device **2130**, as further described below. The button **2133** and/or the flexible translucent membrane **2136** contacts a switch cover located within the device **2130** when the button **2133** is pressed by a visitor. When pressed, the button **2133** may trigger one or more functions of the device **2130**, as further described below.

The motion sensor **2132** may be, for example, one or more passive infrared (PIR) sensors that detect motion using the infrared wavelength, but may be any type of sensor configured for detecting and communicating the presence of motion and/or a heat source within their field of view. The motion sensor **2132** may be configured to detect motion using any methodology, including but not limited to methodologies that do not rely on detecting the presence of a heat source within a field of view, without departing from the scope of the present embodiments. In certain embodiments, the infrared-transparent lens **2132A** may be a Fresnel lens patterned to focus incoming light onto the at least one motion sensor **2132** located within the device **2130**. The infrared transparent lens **2132A** may be substantially coplanar with a front surface of the housing **2131**. In alternative embodiments, the infrared-transparent lens **2132A** may be recessed within the housing **2131** or may protrude outward from the housing **2131**. The infrared-transparent lens **2132A** may extend and curl partially around the side of the device **2130** without departing from the scope of the present embodiments. The at least one motion sensor **2132** is configured to sense a presence and/or motion of an object in front of the device **2130**. In certain embodiments, the optically-transparent lens **2134A** may be configured for focusing light into the camera **2134** so that clear images may be taken. The camera **2134** is configured for capturing video data when activated.

Changes may be made in the above methods, devices, and systems without departing from the scope of the present embodiments. It should thus be noted that the matter contained in the above description and shown in the accompanying drawings should be interpreted as illustrative and not in a limiting sense. The following claims are intended to cover generic and specific features described herein, as well as all statements of the scope of the present method and system, which, as a matter of language, might be said to fall therebetween.

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What is claimed is:

1. A doorbell system, comprising:

a doorbell sound output device controller configured to control flow of electrical power from a transformer to a doorbell sound output device;

wiring; and

a doorbell switch that is separate from the doorbell sound output device controller, the doorbell switch being electrically coupled in parallel with the doorbell sound output device controller via the wiring, the doorbell switch including:

power supply circuitry electrically coupled across the wiring, the power supply circuitry operable to receive input electrical power via the wiring, to electrically power the doorbell switch;

an input device; and

activation circuitry electrically coupled across the wiring, the activation circuitry including a transmitter operably connected to the input device such that, when the input device receives an input to activate the doorbell sound output device, the transmitter generates an activation signal on the wiring, without interfering with ability of the power supply circuitry to receive input electrical power via the wiring, the activation signal being selected from the group consisting of a simple tone and a modulated tone.

2. The doorbell system of claim 1, wherein the activation circuitry and the power supply circuitry are electrically coupled in parallel with the wiring.

3. The doorbell system of claim 1, wherein the transmitter generates the activation signal such that the activation signal is a differential signal on the wiring.

4. The doorbell system of claim 1, wherein the input device comprises a touch-activated switch.

5. The doorbell system of claim 1, wherein the doorbell switch further includes a video camera that generates video image data representing a scene proximate to the doorbell switch.

6. The doorbell system of claim 1, wherein the doorbell switch further includes a microphone that generates sound data representing sound proximate to the doorbell switch.

7. A doorbell system, comprising:

a doorbell sound output device controller configured to control flow of electrical power from a transformer to a doorbell sound output device;

wiring; and

a doorbell switch that is separate from the doorbell sound output device controller, the doorbell switch being electrically coupled in parallel with the doorbell sound output device controller via the wiring, the doorbell switch including:

power supply circuitry that receives input electrical power via the wiring to electrically power the doorbell switch;

an input device; and

perturbation circuitry including a perturbation switching device and an impedance device electrically coupled in series across the wiring, the perturbation circuitry operably connected to the input device such that, when the input device receives an input to activate the doorbell sound output device, the perturbation circuitry generates an activation signal on the wiring by closing the switching device to change electrical current flowing through the wiring, without interfering with ability of the power supply circuitry to receive input electrical power via the wiring.

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8. The doorbell system of claim 7, wherein the doorbell switch further includes activation circuitry including the perturbation circuitry, wherein the activation circuitry and the power supply circuitry are electrically coupled in parallel with the wiring.

9. The doorbell system of claim 7, wherein the impedance device comprises one or more resistors.

10. The doorbell system of claim 7, wherein the input device comprises a touch-activated switch.

11. The doorbell system of claim 7, wherein the doorbell switch further includes a video camera that generates video image data representing a scene proximate to the doorbell switch.

12. The doorbell system of claim 7, wherein the doorbell switch further includes a microphone that generates sound data representing sound proximate to the doorbell switch.

13. A method for operating a doorbell sound output device, the method comprising:

receiving input electrical power at power supply circuitry of a doorbell switch, via wiring electrically coupling the doorbell switch in parallel with a doorbell sound output device controller external to the doorbell switch; powering the doorbell switch from the power supply circuitry;

receiving a command input at the doorbell switch; in response to receiving the command input, generating a tone on the wiring electrically coupling the doorbell switch in parallel with the doorbell sound output device controller while receiving input electrical power at the power supply circuitry via the wiring electrically coupling the doorbell switch in parallel with the doorbell

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sound output device controller, the tone being selected from the group consisting of a simple tone and a modulated tone;

receiving the tone at the doorbell sound output device controller; and

in response to receiving the tone at the doorbell sound output device controller, enabling flow of electrical current between the doorbell sound output device controller and the doorbell sound output device.

14. The method of claim 13, wherein the tone is a differential signal on the wiring electrically coupling the doorbell switch in parallel with the doorbell sound output device controller.

15. The method of claim 13, further comprising detecting, at the doorbell sound output device controller, a signal having a frequency of the tone.

16. The method of claim 13, further comprising filtering the tone from other signals received at the doorbell sound output device controller.

17. The method of claim 13, further comprising: operating a switching device in a conductive state to enable flow of electrical current between the doorbell sound output device controller and the doorbell sound output device;

receiving, at the doorbell sound output device controller, a configuration command; and

adjusting, in response to the configuration command, a duration that the switching device operates in its conductive state.

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